National Aeronautics and Space Administration

Jet Propulsion Laboratory
California Institute of Technology

Date: June 13, 2002

Terrestrial Planet Finder Technology Demonstration Mirror (TDM)

Technology Announcement

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Technology Announcement

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TECHNOLOGY ANNOUNCEMENT

The Terrestrial Planet Finder (TPF) mission will detect and characterize Earth like planets around solar like stars, and search for life beyond our solar system. This Technology Announcement (TA) solicits proposals for demonstrating technologies in support of preparations for the TPF mission. Participation is open to all categories of U.S. organizations, including industry, universities, nonprofit organizations, Federally Funded Research and Development Centers (FFRDC), NASA Centers, and other government agencies. Only U.S. technology providers may propose, foreign proposals are not allowed.

Two observational approaches are being considered for accomplishing the TPF mission goals; IR interferometry, and visible coronagraphy. This solicitation specifically seeks proposals for a technology demonstration primary mirror consistent with the coronagraphic approach. A viable proposal shall offer to design, fabricate, test, evaluate, and deliver a 2 meter class technology demonstration mirror that complies with the specifications described in Appendix A and references therein.

Proposal evaluation will be done using a technical peer review process as described in Appendix D. The selection criteria for evaluation and their relative importance are summarized below and explained in Appendix C.3.

- Technical merit and benefits to TPF (30%)
- Technology maturation (30%)
- Management and implementation plan (40%)

The TDM selection process will occur in two steps. Selected proposers will initially carry out a three-month Technology Concept Definition Study Phase ("Study Phase"). In the Study Phase, each prospective technology provider will be required to produce a detailed preliminary design for the proposed technology demonstration mirror and document the design in a final study report (refer to Appendix E), which will serve as the primary basis for down-selection to the Demonstration Phase. Only the technology providers selected for the Study Phase will be considered for the Demonstration Phase. Therefore, NASA/ JPL will solicit, negotiate, and award contracts (or other agreements) through completion of the Demonstration Phase without further competition.

The Study Phase will involve developing a detailed preliminary design for a technology demonstration mirror as summarized in Appendix C.4.a. The Demonstration Phase will involve final design, fabrication and test, evaluation, and delivery of the technology demonstration mirror as summarized in Appendix E.4.a. A technology demonstration mirror concept appropriate for this TA should be mature enough to demonstrate its capabilities and performance in a relevant environment within three years from the start of the Study Phase.

Any proposals from government, national laboratory, or FFRDCs sources that are substantially the same as an industry or university proposal will be rejected. Accordingly, the government, national laboratory, or FFRDC proposal will not be evaluated and will be returned to the originator.

As many as three (3) technology concept proposals may be selected for the Study Phase. Study Phase fixed price contracts (or other agreements) are anticipated to be valued up to a maximum of $250,000.00 each. At the end of the Study Phase, approximately one (1) technology concept will be down-selected for the Demonstration Phase. The total funding available for all Demonstration Phase activities is anticipated to be approximately $6.0 million. In all cases, JPL's obligation to fund awards is contingent upon the availability of funds and the receipt of proposals that are determined acceptable for award under this TA.

The following information applies to this TA:

Date of TA issue:	June 13, 2002
Notice of Intent to Propose Due:	July 3, 2002
Proposal Due Date:	July 11, 2002 at 3:00 p.m. PDT
Study Phase Start Date (approximately):	August 14, 2002
Proposal Page Limit:	20 Pages
Required Number of Proposals:	Submit fifteen (15) copies and (1) PC readable electronic copy .pdf file format on 3.5-inch disk or ZIP disk, or CD-ROM
Mailing address:	Jet Propulsion Laboratory 4800 Oak Grove Drive, Mail Stop 190-220 Pasadena, CA 91109-8099 Attn: William D. Kert
Address for hand delivery:	Jet Propulsion Laboratory Visitor Control Center Building 249 4800 Oak Grove Drive Pasadena, CA 91109-8099 Attn: William D. Kert
Initiation of funding:	With contract (agreement) award
General Point of Contact:	Mr. William D. Kert Jet Propulsion Laboratory 4800 Oak Grove Drive, M/S 190-220 Pasadena, California 91109-8099 e-mail: william.d.kert@jpl.nasa.gov Telephone: (818) 354-2992

If you have any questions about this TA, please contact Mr. William D. Kert.

Original signed by

Daniel R. Coulter,
Manager, Terrestrial Planet Finder

APPENDIX A

TPF TECHNOLOGY DEMONSTRATION MIRROR REQUIREMENTS

Note: JPL reserves the right to change, as needed, this Appendix and Equipment Specification contained herein, at the commencement of Demonstration Phase activities.

A.1 INTRODUCTION

The TPF mission will search for Earth-like planets around nearby stars, provide the first direct images of such planets and provide low resolution spectroscopic data on planetary atmospheres. In addition, TPF will support general astrophysics studies by providing unprecedented imaging capability. This solicitation seeks proposals for a technology demonstration primary mirror that can demonstrate readiness to realistically begin TPF flight mirror design and development in the 2010 time frame and delivery by 2014. Additional TPF information is at: http://tpf.jpl.nasa.gov/

A.2 TDM SCOPE

The TDM procurement will occur in two phases. The main deliverables for each phase are:

1. Study Phase
   a. A TDM preliminary design review presentation to the TPF science and engineering communities, with the intent of providing the broadest possible dissemination of information, and discussion of system-level issues
   b. A three volume Study Phase Final Report (refer to Appendix E) that describes:
      - The preliminary design of the technology demonstration mirror
      - The Demonstration Phase Technical Plan for final design, fabrication, testing, evaluation, and delivering the technology demonstration mirror and associated ground support equipment, and a separate costed option for completing a program of protoflight qualification testing before delivery
      - The management and cost plan for implementing the Demonstration Phase Technical Plan and any options like protoflight qualification testing

2. Demonstration Phase
   a. The TDM assembly (mirror, mounts and flexures, strongback)
   b. An appropriate TDM container to prevent damage during transport / storage
   c. TDM handling equipment and unique test equipment built under this contract
   d. TDM Test Report including witness samples
   e. TDM Acceptance Data Package including among other things:
      i. An optical performance predicative model for zero g conditions
      ii. An optical performance predicative model for one g conditions
      iii. A manufacturing plan document describing the end-to-end procedure for TDM design and fabrication
   f. A plan for designing, fabricating, testing and delivering a TPF flight primary mirror

Details on the complete scope of work and deliverables for each phase are in later appendices.

A.3 TECHNOLOGY DEMONSTRATION REQUIREMENTS

The TDM shall be fully space flight-like in form, fit and function, and allow assessment of its design to meet all key optical, thermal, structural and lifetime performance requirements consistent with protoflight test environments. The unit and packaging design shall be based on flight-worthy radiation hard, high reliability materials, parts and processes that are compatible with the space environment and specified flight operating temperatures, and radiation conditions.

The TDM shall be capable of providing the required optical performance over the full range of space flight mission conditions, and be suitable for use by a TPF precursor mission, if such an opportunity arises.

The achievement of very low spatial frequency error is crucial for a successful TDM since it is the major factor in determining the level of starlight supression achievable in a TPF coronagraph system. Mirror mass, or areal density, is another critical factor with respect to the application of this technology since the primary mirror can account for a significant fraction of the launch mass of a large space telescope system. For this reason, a low areal density TDM is highly desirable. However, recognizing that excessive lightweighting may limit the achievable spatial frequency error, a rather conservative areal density specification is given along with a more aggressive goal. Proposers should strive to achieve the lowest practical areal density TDM consistent with the specified spatial frequency error profile.

A.4 ATTACHMENTS

The following attachment to Appendix A provides detailed requirements and specifications for a Technology Demonstration Mirror.

a. TDM Detailed Equipment Specification

Terrestrial Planet Finder

Technology Demonstration Mirror (TDM)

PRELIMINARY

DETAILED EQUIPMENT SPECIFICATION

Proposers are permitted to suggest changes to this preliminary specification, especially where values are “TBD” (to be determined), and “TBR” (to be refined).

1.0 Scope and Precedence of Requirements

This specification defines the requirements for the design, fabrication, and verification of a deliverable TPF Technology Demonstration Mirror (TDM). The specified mirror constitutes technology demonstration. The essence of this demonstration is to achieve the mid-spatial frequency requirements, both in surface error and in reflectance nonuniformities. Surface error requirements in the mid-spatial frequencies are better than that achieved on Hubble Space Telescope (HST), and in addition, in a more challenging geometry. The TDM is an unobscured section of a steep aspheric profile, on a substrate roughly one-third to one-quarter the areal density of HST, which is why the mid-spatial frequency requirement is very challenging. Furthermore, the TDM goal is 2 times better than required as identified by TPF architecture studies.

While NASA has not identified a flight mission for the TDM, the delivered mirror is to demonstrate the level of technology that can currently be produced to flight standards.

1.1. Purpose

The TDM mirror described in this specification is targeted at demonstrating technology relevant to architecture studies for coronagraphic TPF missions.

1.2. Conflicting Requirements

Conflicts arising between the requirements of this specification and the requirements of any document referenced herein shall be referred to the TDM Contract Technical Manager (CTM) for resolution.

1.3. Technical Monitoring

In order to monitor the progress of this effort, a cognizant JPL CTM will request technical interchange meetings consistent with the Technology Announcement (TA).

2.0 Relevant documents

The TDM mirror assembly shall be designed, fabricated and tested in compliance to this specification, definition of work in the TA, and documents listed below.

2.1. Precedence: Should there be a conflict in interpretation of requirements, the order of precedence is:

1st	TA
2nd	Specification
3rd	Sub tier documents listed below

2.2. Documents:

2.2.1. JPL Guideline D-17868: Design, Verification/Validation and Operations Principles for Flight Systems, Rev. 1

2.2.2. Specification/Standards Documents

MIL-F-48616	Mild abrasion/Humidity/Adhesion
MIL-O-13830 H	General Specification, Manufacture, Assembly, and Inspection
ASTM F 1811-97	Measurement of power spectral density function (PSD)

3.0 Definitions

3.1. Level of requirements: The word "shall" constitutes a mandatory requirement, while the word "will" constitutes a sub-tier requirement, and does not take precedence over the "shall" statement of that requirement elsewhere in this document. "Will" may also denote a goal.

3.2. Coordinate system

3.2.1. The TDM mirror coordinate system is defined in terms X, Y and Z-axis in the following configuration and as shown in Figure 3-1:

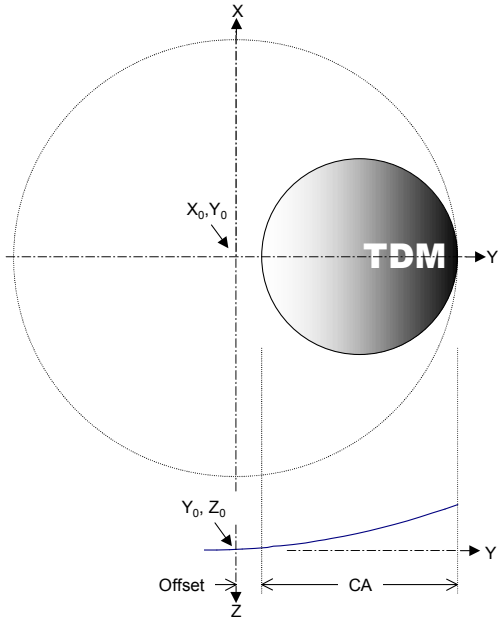


Figure 3-1: Cartesian Coordinate System

3.2.2. Z is the axis normal to the parent vertex and facing into the surface

3.2.3. Y is the axis along the radius vector of the parent, including both the center of the parent and the center of the TDM.

3.2.4. For data reported to JPL, any alternative coordinates systems evoked must be referenced to this system, and a transformation matrix provided.

3.3. Design Practices

The contractor shall specify the approach to be used and the extent to which metric (SI) units of measurement will be used to meet the requirements of this specification. Use of metric units shall be assumed for new designs unless it can be demonstrated to result in significant inefficiencies.

3.4. Aperture Definitions

3.4.1. Offset Distance: Y1 is the distance between the optical axis (center of the parent) and the nearest edge of the TDM beyond which all specified optical and coating properties are fully satisfied.

3.4.2. Physical Aperture (PA): Includes the maximum physical diametric aperture of TDM front surface, allowing for clear aperture roll off, bezels and non-circularity.

3.4.3. Clear Aperture (CA) is defined as the diameter of the TDM within which all specified optical and coating properties are fully satisfied. The CA is circular in projection on the XY plane. The TDM surface is inclined to the XY plane, and as such, the clear aperture would be slightly elliptical. JPL will consider a contractor request to make the CA circular along the mirror surface, provided this does not reduce the collecting area of the telescope. The Clear Aperture Allowance (CAA) is the (PA – CA)/2 which may be anisotropic, and is provided for the convenience of optical fabrication. CAA0 is the CAA along the Y axis nearest the optical axis.

3.4.4. Greatest Lateral Extent (GLE): Includes the TDM Physical Aperture, plus any part of the TDM front or back, projected on the XY plane. The GLE also includes tolerance build-up, and may be anisotropic.

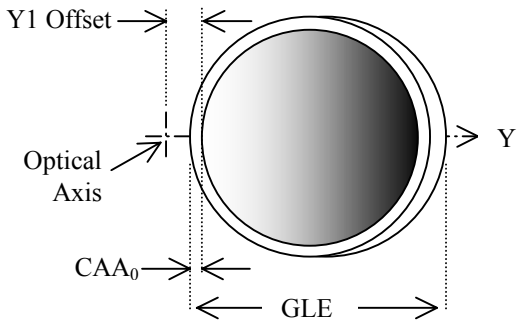


Figure 3-2: Greatest Lateral Extent

3.5. Conic Constant: The conic constant, as used in this document, follows the convention of Malacara (Optical Shop Testing, 2nd edition, 1992, Appendix 1) and is denoted as K. In this convention, a paraboloid has K = -1, and an ellipse rotated around its major axis has $-1 < K < 0$.

3.6. Surface Errors

3.6.1. Spatial wavelengths (Λ) are defined to cover the following ranges:

3.6.1.1. Low spatial wavelengths: $\Lambda > 40\text{cm}$

3.6.1.2. Mid spatial wavelengths (critical): $40\text{cm} \geq \Lambda \geq 2\text{cm}$

3.6.1.3. High spatial wavelengths: $2\text{cm} > \Lambda > 1\text{mm}$

3.6.2. The Power Spectral Density (PSD) shall be derived from a surface figure error map inclusive of 100% of the area contained within the clear aperture. PSD will be calculated in a manner consistent with ASTM F 1811-97. Surface error is defined to be parallel to the optical axis.

The optical finishing figure-of-merit over the low, mid, and high spatial frequency regime is the PSD, with piston, tip, tilt, and focus subtracted. A 2-dimensional

PSD is to be computed from a residual surface figure map and provided in digital form. The raw surface figure error data shall be provided in digital form as a function of mirror surface coordinates. Coordinates and units shall be identified. Test and data analysis uncertainty shall be allocated in the test error budget.

The contractor is encouraged to over sample to achieve accurate measures of the PSD (Goal is > 5x Nyquist). It is recognized that rich sampling will introduce spurious points. During the study phase, the contractor may offer a schedule of point count that may fall outside the specified PSD, yet not be counted in meeting the specification. JPL reserves the right to modify or reject this approach. The approach must include a rationale for selection of points that will not be included in the PSD. Any such criteria must not result in ignoring a defective zone in either the frequency regime or spatial regime. At least 95% of the data shall be included.

3.6.3. Microroughness is a sampled quantity and represents the contribution to veiling glare resulting from surface error at spatial wavelengths ~1μm < Λ < 1mm.

3.6.4. Microroughness shall be measured in mutually agreed locations within the clear aperture. Typically, this measurement is made using a non-contact profilometer, Atomic Force Microscope (AFM) or scatterometer, or some combination of these instruments.

3.7. Metrology

The contractor shall provide a detailed test procedure, including an error allocation among various effects covering the full domain of spatial frequencies. These effects may be dependent on the spatial wavelength (Λ) domain under consideration, and are listed in section 3.7.

3.8. Error Budgets

The contractor shall provide a comprehensive error budget as part of the TDM design, defining in depth both random and uncompensated systematic error contributions. The error budget is not merely a high level representation of the TDM, but rather a detailed multi-level tool that may be used to evaluate and understand design trades and sub-tier requirements. At least four error budgets shall be provided for surface errors, and at least one error budget for coating errors. Each shall demonstrate how the requirement is met. The budgets are as follows:

Error Budget (Surface, Λ>40cm)
Error Budget (Surface, 40cm≥Λ≥2cm)
Error Budget (Surface, 2cm>Λ>1mm)
Error Budget (Surface, 1mm>Λ>1μm)
Error Budget (Reflectance, 40cm≥Λ≥2cm)

Error estimates shall recognize both broad spatial frequency effects and anticipated periodic or zonal deviations. Narrow spatial frequency error effects must be noted and included in the error budget. An error budget shall explicitly define how each element is propagated to the next higher level, and state the basis for estimation of the lower tier contributors. If errors cannot be combined automatically, the basis of combination shall be explained. Each error budget shall be delivered as an "active electronic document", preferably as an Excel spreadsheet.

The error budget shall represent effects to at least the 3rd level. Error elements shall include all known relevant random and uncompensated systematic effects, including, but not limited to the following:

- Calibration errors
- Mounting errors
- Test vibration errors
- Test seeing errors
- Sampling errors
- Metrology noise
- Systematic instrument errors
- Mounting repeatability
- Gravity release residual errors
- Uncertainties in combination of observations
- Registration errors
- Temperature offset, gradient and transient errors
- Material inhomogeneity and anisotropy
- Coating stress (global and print through deformation)
- Contamination
- Aging

4.0 Optical Characteristics

4.1. Optical prescription

4.1.1. The conic constant shall be (-0.996622) ± 0.0001 (knowledge within ±0.00001).

4.1.2. The vertex radius of curvature shall be 7200 mm ± 2 mm (knowledge within 0.05 mm).

4.1.3. The parent vertex and the center of the TDM mirror shall be separated by 1100 mm ± 2 mm (knowledge within 0.1 mm).

4.2. Surface definition

4.2.1. Zones

4.2.1.1. The clear aperture (CA), circular in projection on the XY plane, is ≥ 1800mm in diameter in that projection.

4.2.1.2. The clear aperture allowance shall be ≤ 40mm in the plane of the mirror.

4.2.1.3. Greatest Lateral Extent (GLE) shall be ≤ 1900mm along Y.

4.2.1.4. The Physical Aperture shall be ≤ 1880mm along X.

4.2.2. Surface Requirements

The PSD will be derived from surface figure map and includes 100% of the area contained in the clear aperture.

4.2.2.1. Spatial frequency error content

4.2.2.1.1. Over 1mm < Λ < full aperture, residual data points at all frequencies shall be plotted as a function of spatial frequency and shall fall under the required PSD curve sampled at least 2 times the Nyquist frequency with 5 times Nyquist as a measurement goal. Sub-aperture measurement may be necessary to adequately sample the highest spatial frequencies.

The required PSD curve as a function of the spatial frequency, *k*, is defined as:

$$PSD(k) = \frac{A}{1 + \left(\frac{k}{k_o}\right)^n}$$

Where $k = \frac{1}{\Lambda} = \sqrt{(k_x^2 + k_y^2)}$ cycles/cm

A = 2.4 * 10^5 Angstroms^2 cm^2

(goal is A = 6 * 10^4 Angstroms^2 cm^2 between Λ = 40cm and Λ = 2cm)

k_o = 0.04 cycles/cm

n = 3

The surface figure of the mounted mirror, corrected to zero-gravity conditions, shall be measured in a manner that provides a map of surface figure structure on all spatial scales.

4.2.2.1.2. For the low and mid spatial frequencies a smoothing function shall be applied to the surface figure map to remove by averaging all surface structure on spatial scales smaller than 2 centimeters. The PSD of the surface figure shall be estimated from this filtered surface figure map. The estimated PSD values shall fall below the specified PSD curve over the spatial frequency range from 0.025 to 0.5 cycles / centimeter. Exceptions to this requirement will be allowed, to an extent not to exceed the specified PSD by more than a factor of 2 within a spatial frequency range no greater than 10% of the specified spatial frequency range.

4.2.2.1.3. Over the microroughness regime of ~1μm < Λ < 1mm, the residual surface error must be less than 10Å rms with a goal of 5Å rms. Sampled locations will be measured in both radial and azimuthal directions (referenced to the center of the TDM) at ≥ 6 mutually agreed

locations defined during the design phase. One of these locations must include the visual "worst" location on the mirror as assessed by high intensity light illumination in a darkened room. Scan length shall be ≥ 10mm, and the spatial filter will be set to yield results comparable to industry standards, and representative of the level of total integrated scatter (TIS) expected from the sample location on the mirror. Derived values may exclude the amplitude of a mapped scratch or dig at the location of the measurement. The level of the mirror is regarded to be the average of the 12 or more measurements above. All measurements shall be reported, and the scans provided in electronic form.

4.2.2.2.Cosmetic quality

The polished clear aperture of the mirror substrate shall meet or exceed a Scratch/Dig of 80/50 per MIL-O-13830H.

4.2.3. Sequence of optical performance testing

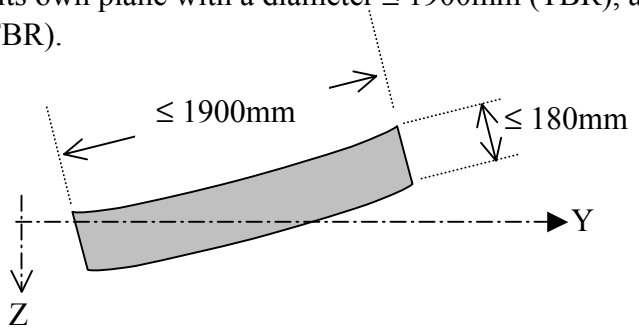
4.2.3.1. Conclusion of optical fabrication prior to mounting
4.2.3.2. After mounting in mirror assembly, prior to gravity release
4.2.3.3. During gravity release, prior to thermal cycling
4.2.3.4. After thermal cycling and prior to protoflight vibration/acoustic/shock test
4.2.3.5. After vibration/acoustic/shock test
4.2.3.6. After coating

4.3. Reference fiducials: The manufacturer shall design and provide a system of fiducials on the mirror appropriate to aid in post-delivery testing, and in integrating the mirror into a telescope assembly. The design shall be compatible with metrology, and will establish the spatial position of the mirror relative to the parent mirror's vertex and optical axis. It is anticipated that final adjustment of the position of the mirror will be determined by testing optical attributes, and accordingly, the fiducials may not be required to satisfy the full telescope alignment flow down allocated to the Primary Mirror. Alignment fiducials will be either registered to the mirror following a kinematic mounting scheme, or will be integral to the mirror. In either case, accuracy must be met for each Degree-of-Freedom. In the former case, an additional registration repeatability requirement will be satisfied.

Degrees of Freedom	Accuracy	Repeatability	Units
$\Delta X = \pm$	200	20	mm
$\Delta Y = \pm$	200	20	mm
$\Delta Z = \pm$	200	20	mm
$\theta_X = \pm$	26	3	milliradians
$\theta_Y = \pm$	26	3	milliradians
$\theta_Z = \pm$	175	20	milliradians

5.0 Mirror Substrate

5.1. The mirror substrate, if fabricated along the off-axis angle of the mirror, shall have a physical aperture in its own plane with a diameter ≤ 1900mm (TBR), and thickness at the edge of ≤ 180mm (TBR).



5.2. The substrate material must be compatible with maintaining a stable boresight and satisfying surface requirements while exposed to temperatures per section 7.4.

5.3. The substrate material must be compatible with launch and operational loads when implemented on a lightweight structure.

5.4. The substrate material must be dimensionally stable and sustain all optical figure requirements for at least 3 years of storage in earth ambient conditions, and 10 years of space flight.

5.5. The substrate material must be dimensionally stable and sustain a total ionizing dose (TID) per the specifications in section 7.4 while sustaining all optical figure requirements.

5.6. The mirror must have a first resonant frequency ≥ 200Hz (300Hz goal TBR). Unsupported sections of the face sheet spanning lightweighting pockets should have a resonant frequency ≥ 2500Hz (TBR)

5.7. The substrate areal density, including mounting interfaces, shall be < 60kg/m^2 (TBR), with a goal of 30kg/m^2 (TBR)

5.8. Interface pads

5.8.1. Mounting distortion is included in the surface figure requirement, and is to be represented during test

5.8.2. The mirror shall be kinematically mounted via a set of 3 bipods, located at the support points that will minimize gravitational deflection,

5.8.2.1. The mount shall be consistent with TBD coronagraph instrument packaging and mounting constraints, and maximize support under launch loads. One mirror mount shall lie on the projection of the Y axis, and shall be on the side of the TDM furthest from the optical axis of the parent.

5.9. Venting requirements

5.9.1. Maximum differential pressure shall be < 0.2 atmospheres while depressurizing at the maximum environmental rate.

5.10. TDM Assembly

5.10.1. The TDM Assembly consists of

5.10.1.1. TDM mirror

5.10.1.2. Mounting pads

5.10.1.3. 3 kinematic bipod mounts, designed / fabricated to protoflight standards

5.10.1.4. A surrogate strong back that will hold the mirror, and represents that structure that, in a hypothetical system, would relate the TDM to the rest of the telescope, to the instrument package, and to the spacecraft. Location of mount points on the surrogate strong back is TBD.

5.10.2. Testing and validation in the TDM Assembly configuration

5.10.2.1. Performance and environmental tests shall be performed with the TDM in the TDM assembly, with all fasteners at proper torques

5.10.2.2. Accessory supports for gravity offload tests may be used. Analytic estimates of errors in such offload supports shall be a component in the final mirror error determination.

5.10.3. TDM Assembly Characteristics

5.10.3.1. The TDM assembly shall have a first resonance frequency ≥ 80 Hz (TBR)

5.11. The TDM shall be compatible with maintaining Class 500 cleanliness requirements. As such, the bevel, edge and backsheet shall be finished in a manner to minimize contamination issues.

6.0 Mirror Coating Definitions

The requirement for the mirror coating shall be an unprotected reflective metallic film, and the reflectance will be equal to freshly deposited pure gold. The uniformity of reflectance over the clear aperture, not the absolute value of the reflectance, is the essence of the coating requirement.

In the specifications that follow, reference is made to both witness samples and test coupons. Witness samples are coated along with the TDM while test coupons are coated during special coating runs that are identical in all coating parameters to the coating run used to coat the TDM. The location of each witness sample, with respect to the TDM, shall be recorded. The location of the test coupons with respect to the geometry to be used to coat the TDM shall be recorded.

6.1. **Spectral Characteristics.** The reflectance of the TDM mirror specular surface is equivalent to the reflectance of Au without overcoat. The TDM mirror will operate over a spectral wavelength band from 0.55μm to 2.50μm. Tests shall cover this spectral range. The coating reflectance shall be ≥ reflectance of bare freshly deposited gold minus 1% at Beginning of Life (BOL), and within minus 2% of bare freshly deposited gold at End of Life (EOL).

6.2. **Coating Area.** Coating shall extend beyond the clear aperture but not across an edge onto any edge bevel. Within the clear aperture, coating reflectance uniformity and reflectance requirements shall be satisfied.

6.3. **Coating Deposition Process.** The coating deposition process shall be consistent with satisfying all TDM requirements, with emphasis on lifetime, reflectance uniformity, low scatter, and minimal surface error over all spatial frequencies. The supplier's ability to clean the reflective surface of molecular and particle contamination by a process the supplier provides, is a TDM goal. Any induced polarization or phase retardance will be included in the reflectance uniformity and surface error uniformity requirements to the extent they affect these attributes.

6.4. **Coating Reflectance Uniformity.** Within the TDM clear aperture, and over spatial wavelength bands between $2\text{cm} \leq \Lambda \leq 40\text{cm}$, the RMS residual reflectance shall be $\leq 0.3\%$, with $\leq 0.1\%$ the goal. Metrology directly on the TDM mirror is preferred. However, as a less favorable option, the supplier may extrapolate the reflectance uniformity of the mirror from a dense set of planar test coupons set at a comparable angle and spacing to the source, and exposed immediately before or after the TDM under identical deposition conditions. In the case of the less preferred option, test coupons shall represent the entire TDM surface. JPL will consider sampling strategies to reduce the number of measurements needed, provided that the full surface is sampled in this strategy is justified based on coating technique and/or on coating demonstrations.

6.5. **Straylight**. Any contribution of the mirror coating to stray light shall be included in the microroughness specification. The TDM mirror will be subjectively inspected in a dark room with a collimated high intensity light. Areas that exhibit anomalous brightness shall be included in sampling should metrology directly on the TDM mirror be possible.

6.6. **Ionizing Radiation**. The mirror coating shall show no signs of degradation, cloudiness or discoloration after test coupons are subjected to 1.5 times the TID level specified. After irradiation the mirror coating on the sample shall be examined with 10X microscope and shall show no evidence of flaking, peeling, cracking or blistering. This test shall use the same substrate material as is used for the TDM.

6.7. **Humidity Resistance.** The mirror coating shall show no signs of deterioration such as tarnishing after witness samples are subjected to tests specified in MIL-F-48616.

6.8. **Adhesion.** The mirror coating shall show adhesion when subjected to tests specified in MIL-F-48616. Witness samples shall be used for this test.

6.9. **Mirror Coating Stress**. The mirror optical coating shall not produce significant stresses in the mirror. The optical surface of the mirror shall meet all requirements in section 4.2.2 after mirror coating. This shall be determined by comparing full aperture phase maps taken of the TDM optical surface before and after coating.

6.10. **Mirror Coating Surface Quality**. The finished TDM mirror coating shall comply with MIL-0-13830 H. The mirror coatings shall exhibit no structural non-uniformity, sleeks, or scratches larger than 80/50 when inspected with the unaided eye.

6.11. **Mirror Witness Samples.** The contractor shall manufacture an appropriate number of the witness samples. The witness samples shall be 25mm (TBR) size, fabricated using the same mirror substrate material; polished by same process the mirror substrate is polished, and coated with an identical mirror coating process as the TDM mirror. The test lot size shall be 20 (TBR) pieces.

6.12. **Contamination Control**. The coated TDM shall be kept in a contamination controlled area during metrology/storage/shipping at a Class 500 cleanliness level.

7.0 Environment Compatibility Verification

7.1. TDM Lifetime

7.1.1. The pre-launch storage lifetime (within shipping container) is 2 years.

7.1.2. The pre-launch telescope integration lifetime is 3 years, at integration environment.

7.1.3. The space flight lifetime shall be 5 years, with a goal of 10 years.

7.2. The TDM shall survive the following launch environment (non-operating) conditions

7.2.1. Temperature: -10°C to +60°C

7.2.2. Pressure: 15 psi to $< 10^{-6}$ Torr

7.2.3. Pressure change: Specified range above over a 5 minute period

7.2.4. Humidity: 0 to 50% RH

7.3. Protoflight Qualification Requirements:

7.3.1. **Structural Loads**: The TDM and supporting struts shall be designed to a limit load value of 12 g's applied in the worst single direction through the center of gravity of the TDM. Minimum design factors are 1.4 on ultimate and 1.25 on yield. Qualification test requirement is 1.25 x limit load. The qualification loads may be applied by a static loads test, a centrifuge test, or a shaker pulse test.

7.3.2. **Random Vibration**: The TDM assembly (bipods and strongback included) shall be subject to the random vibration qualification levels given below. The test duration is two minutes in each of three orthogonal axes. The test may be force limited to reduce over-test at hard mounted resonance frequencies. The upper bound force spectrum below may be used to limit the input acceleration to the test article. Additional notching of the input acceleration spectrum may be applied if necessary to keep the interface force from exceeding the structural limit load.

Primary Mirror Random Vibration Qualification Test Acceleration Input

Frequency, Hz	Acceleration Spectral Density Level
20	$0.015 g^2$ / Hz
20 – 80	+ 3 dB / Octave
80 – 500	0.06 g^2 / Hz
500 – 2000	-6 dB / Octave
2000	0.00375 g^2 / Hz
Overall	7.1 g rms

1g = standard acceleration due to gravity = 9.81 m/s^2

Duration: 2 minutes in each of three orthogonal axes

Primary Mirror Random Vibration Qualification Test Force Limit Specifications

Frequency, Hz	Force Spectral Density Level
20 – 1.1 Fn 1.1 Fn - 1000	480 FN^2 / Hz - 6 dB / Octave

Where Fn is the first predominate resonance frequency in the axis of test, F is the product of the acceleration spectrum times the square of the total mass of the test article in Kg, N is the unit Newtons

7.3.3. **Acoustic Noise:** The acoustic noise qualification requirement for the TDM is a reverberant random-incidence acoustic field specified in 1/3 octave bands. The acoustic noise spectra are specified below. The flight qualification test exposure time is 2 minutes, but the flight acceptance test exposure time is only 1 minute.

Acoustic Qualification Test Level

1/3 Octave Band Center Frequency (Hz)	Qualification Sound Pressure Level (dB ref. 20 microPa)	Test Tolerances
31.5	122.5	+5, -3
40	125.5	+5, -3
50	129.5	+5, -3
63	131.0	± 3
80	133.0	± 3
100	133.0	± 3
125	133.0	± 3
160	133.5	± 3
200	134.5	± 3
250	135.5	± 3
315	134.5	± 3
400	131.0	±3
500	128.0	± 3
630	125.0	± 3
800	123.0	± 3
1000	121.0	± 3
1250	120.0	± 3
1600	119.5	± 3
2000	119.0	± 3
2500	118.0	± 3
3150	116.5	± 3
4000	114.0	± 3
5000	110.0	± 3
6300	106.0	± 3
8000	103.0	± 3
10000	101.0	± 3
Overall	143.6	± 1
Duration:	Qual: 2 minutes	

7.3.4. **Pyrotechnic Shock:** Pyrotechnic shock qualification requirements are shown below. The pyroshock requirement is defined as a shock response spectrum (SRS) for a frequency range of 100 to 10,000 Hz, which is intended to represent the structurally transmitted transients from pyrotechnic devices used to achieve various separations. The shock pulse, with the SRS corresponding to this specification, shall be applied to the assembly mounting points in each of three orthogonal axes. The synthesized shock waveform shall meet the following criteria:

1. The time history shall be oscillatory in nature, and
2. The pulse shall decay to less than 10% of its peak value within 20 milliseconds.

Primary Mirror Pyrotechnic Shock Qualification Test Requirement

Frequency, Hz	Peak SRS Response (Q=10)
100 100 - 1,600 1,600 - 10,000	10 g + 10.0 dB / Octave 1000 g

1g = standard acceleration due to gravity = 9.81 m/s^2
Two shocks for QUAL in each of the three orthogonal axes.

7.3.5. **Thermal:** The TDM shall be exposed to 3 cycles over the survival temperature range (see section 7.4) with a temperature ramp ≤ 1ºC/minute.

7.4. Operational Space Flight Environment

7.4.1.	Gravity environment	<0.005g
7.4.2.	Operating temperature	20 ±2 °C
7.4.3.	Survival temperature range	-30°C to +60°C
7.4.4.	TDM thermal gradients	Front to back < 2°C, Radial <1°C
7.4.5.	TDM thermal transients	dT/dt < 1°C/minute
7.4.6.	Pressure	$< 10^{-6}$ Torr
7.4.7.	Ionizing radiation	20,000 rad (Si) total dose (TBR) in 5 years (witness sample includes materials in addition to substrate and coating not included in other sections)

7.5. Storage
Temperature between 10 and 30 degrees C, at less than 5% relative humidity

7.6. Integration
Temperature between 5 and 35 degrees C, at less than 80% relative humidity

8.0 Quality Assurance

8.1. Responsibility for Quality Assurance

Primary responsibility for quality assurance of delivered hardware, processes, tests, or services is placed on the contractor, who is responsible for offering only those hardware, processes, tests, or services that conform to specified requirements. The contractor shall implement a quality assurance program to assure that the requirements of this specification are met.

8.2. Materials and Processes

Materials and processes employed in designing producing the TDM are to be consistent with space flight practices. Specifically, compliance under vacuum conditions, survival temperature range and survival launch loads shall be demonstrated on either the TDM, or a representative surrogate of the TDM. Materials and processes used shall be consistent with an ionizing radiation environment and meet flight standards for outgassing. The TDM optical performance shall be evaluated before and after testing at specified vibration levels and depressurization rates, and demonstrate no resulting degradation. Performance shall also be demonstrated over the operational temperature range.

8.2.1. Traceability

All materials shall be identified with a material lot number. Traceability shall be provided by identifying materials in a particular serialized assembly or subassembly by a procured lot number. This identification shall remain with the material at all times and provide complete traceability information from the procurement source.

8.2.2. Material Review Boards (MRB)

The contractor shall notify JPL in advance of any MRBs including:

a. Type I MRBs that consider issues affecting form, fit, or function relative to the TDM specifications. The contractor shall include JPL in the MRB. The MRB shall be final only after JPL approval.
b. Type II MRBs that consider issues affecting contractor imposed sub-tier requirements. JPL does not necessarily have to be included in the MRB, however, the disposition of the MRB shall be reported to JPL within one week of closure.

8.3. Anomaly Reporting and Corrective Action

The contractor shall notify JPL of any manufacturing failures or anomalies that put at risk the timely completion of deliverables. The contractor shall contact and consult with the JPL CTM in order to plan and gain authorization for corrective action.

8.4. Quality Conformance Inspections and Tests.

TDM compliance with the requirements of this specification shall be verified by one or more of the following methods as indicated in Table 8.4.

a. Inspection - A visual observation, examination, or direct measurement of the physical characteristics of the deliverable item with a comparison to the applicable requirement, yielding a subjective pass / fail evaluation.

b. Analysis - A calculated prediction showing that the deliverable hardware complies with the stated requirements based on measured properties including relevent test data together with analytical models based on the applicable engineering and physical governing equations.

c. Test – A laboratory procedure under controlled conditions yielding multi-valued experimental data, and subsequent data reduction, to provide quantitative data that are directly compared to prescribed requirements.

8.5. Test Documentation

Prior to the conduct of any testing called for by this specification, the contractor shall prepare a test procedure including the testing sequence, the test methods, and the pass/fail criteria for each test. The test procedure shall be submitted to JPL for approval prior to testing. Complete records of all tests shall be kept and made available to JPL. The records shall include the data for each test conducted. A JPL representative shall be notified of test dates so that tests may be witnessed by JPL.

8.6. Test Equipment Accuracies

Unless otherwise agreed to, equipment used to measure unit parameters shall not introduce an error greater than ten percent of the tolerance of the parameter being measured.

Table 8.4 Product Verification Matrix

Paragraph	Parameter	Inspection	Analysis	Test
4.1	**Optical Prescription**			
4.1.1	Conic constant			FA
4.1.2	Vertex radius of curvature			X
4.1.3	Pupil Offset			X
4.2	**Surface Definition**			
4.2.1.1	Clear Aperture	X		
4.2.1.2	Clear Aperture Allowance	X		
4.2.1.3	Greatest Lateral Extent	X		
4.2.1.4	Physical Aperture	X		
4.2.2	**Surface Requirements**			
4.2.2.1.1	Surface Phase Map			FA
4.2.2.1.2	PSD Curve			X
4.2.2.1.3	Microroughness			SS
4.2.2.2.	Cosmetic Quality	X		
4.2.3	Sequence of optical testing	X		
4.3	Reference Fiducials	X		
5.0	**Mirror Substrate**			
5.1	Mirror Dimensions	X		
5.2	Thermal Stability		X	
5.3	Launch Compatibility		X	
5.4	Lifetime		X	
5.5	Ionizing Radiation		X	
5.6	Resonant Frequency		X	
5.7	Mass		X	
5.8	Interface Pads		X	
5.9	Venting		X	
5.10	TDM Assembly		X	
5.11	Cleanliness	X		
6.0	**Mirror Coating**			
6.1	Spectral Characteristics			WS
6.2	Coating Area	X		
6.3	Coating Process	X		
6.4	Reflectance Uniformity			TC
6.5	Straylight	X		
6.6	Ionizing Radiation			TC
6.7	Humidity			TC
6.8	Adhesion			TC
6.9	Coating Stress			FA
6.10	Coating Surface Quality			FA
6.11	Witness Samples	X		
6.12	Contamination Control	X		

7.0	**Environment Compatibility Verification**			
7.1	Lifetime		X	
7.3	Protoflight Qualification Requirements			
7.3.1	Structural Loads			X
7.3.2	Random Vibration			X
7.3.3	Acoustic Noise			X
7.3.4	Pyrotechnic Shock			X
7.3.5	Thermal			X
7.4	Operational Space Flight Environment			
7.4.1	Gravity Environment			FA
7.4.2	Operating Temperature			X
7.4.3	Survival Temperature			X
7.4.4	TDM Thermal gradients		X	
7.4.5	TDM Thermal transients		X	
7.4.6	Pressure			X
7.4.7	Ionizing Radiation			TC
7.5	Storage		X	
7.6	Integration		X	

Legend:

FA – Full aperture
WS – Witness Sample
SS – Subsample
TC – Test Coupon

9.0 Demonstration Phase Preliminary Contract Data Requirements List

During the Study Phase the contractor shall prepare a detailed description of the information to be provided for each CDRL item. Each CDRL item should contain sufficient details to define the engineering results. Documentation (e.g., QA reports, drawing sets, lists) shall be complete.

No.	Item	Due Date
1.0	Blank production plan (include substrate acquisition plan) Material requirements CTE, homogeneity, CTE anisotropy Facesheet seeds, voids, and inclusions Stress and annealing Fracture mechanics plan Structural design Mirror mount design Fabrication plan Slumping requirements Percentage of complete bonds Surface error of the blank Facility plan Blank handling equipment	Delta PDR
1.1	Pre-shipping review presentation package (blank)	
1.2	Blank acceptance data package Pre-ship surface error Inspection reports	
1.3	Results of the tests on the substrate facesheet witness pieces (material properties such as CTE, modulus, etc.)	
1.4	Results of the tests on the core witness pieces measured (material properties such as CTE, modulus, etc.)	
2.0	Structural Design Review presentation package	CDR
2.1	Full parts list (including mirror handling, gravity off-load, measurement system, packaging)	
2.2	Full drawings list (including all items in 2.1)	
2.3	Full set of as-designed drawings (including all items in 2.1)	
2.4	Analysis reports (structural design and model, depressurization analysis, thermal model - as designed)	
2.6	Gravity release report Calculated distortion due to gravity with the TDM in the optical test configuration Design of the gravity release system Assumptions and analysis of this system Test to verify the assumptions and analysis	
2.6.1	Gravity release residual error study Errors determined both by analysis and measurement	

3.0	Coating plan Process to be used for coating Plan to verify coating facility	CDR
3.1	Coating metrology plan	
3.2	Coating aging study (uniformity with time)	
3.3	Pre-shipping review presentation package (to coating facility)	
3.4	Cleaning plan	
3.5	Test coupons Results for reflectivity, reflectivity uniformity, adhesion, humidity and radiation sensitivity, and coating stress	
3.6	Coating readiness review presentation package	
4.0	Test plan	CDR
4.1	Test Readiness Review Verification of metrology system	TRR
4.2	Optical performance test procedures	
4.3	Environmental test procedures Verification of temperature control and vibration isolation system Identification of residual errors due to temperature variations and vibrations	
4.4	Test equipment calibration reports	
4.5	Mirror vertex and directional reference Procedure to be used for verification of the mirror	
4.6	Mirror alignment plan (for test and telescope recommendations)	
4.7	Special test equipment (null lenses, etc.) design	
4.8	Test data (primary and reduced) Surface maps and PSD Modal frequencies	
5.0	Final controlled version of detailed manufacturing plan	PSR
5.1	Manufacturing flow diagram	
5.2	Tooling drawings	
5.3	Handling fixture design - as built	
6.0	TPF Primary Mirror Development Plan	PSR
7.0	TDM Analysis reports (structural, depressurization, thermal - as built)	PSR
7.1	Full set of as-built drawings (red lines acceptable)	
7.2	QA report	

10.0 Acronyms and definitions

AFM	**A**tomic **F**orce **M**icroscope
BOL	**B**eginning **O**f **L**ife
CA	**C**lear **A**perture
CAA	**C**lear **A**perture **A**llowance
CDR	**C**ritical **D**esign **R**eview
CDRL	**C**ontract **D**ata **R**equirements **L**ist
CTM	**C**ontract **T**echnical **M**anager
CTE	**C**oefficient of **E**xpansion
EOL	**E**nd **O**f **L**ife
GLE	**G**reatest **L**ateral **E**xtent
HST	**H**ubble **S**pace **T**elescope
MRB	**M**aterial **R**eview **B**oards
PA	**P**hysical **A**perture
PDR	**P**reliminary **D**esign **R**eview
PSD	**P**ower **S**pectral **D**ensity
PSR	**P**re-**S**hip **R**eview
QA	**Q**uality **A**ssurance
RH	**R**elative **H**umidity
SRS	**S**hock **R**esponse **S**pectrum
TA	**T**echnology **A**nnouncement
TBD	**T**o **B**e **D**efined
TBR	**T**o **B**e **R**efined
TDM	**T**echnology **D**emonstration **M**irror
TID	**T**otal **I**onizing **D**ose
TIS	**T**otal **I**ntegrated **S**catter
TPF	**T**errestrial **P**lanet **F**inder
TRR	**T**est **R**eadiness **R**eview

Definitions

k	Spatial Frequency in Cycles Per Centimeter
K	Conic Constant
Λ	Spatial Wavelength

APPENDIX B

General Instructions for Responding to this Technology Announcement

B.1 GENERAL PROVISIONS AND POLICIES

A "Technology Provider" is the single person responsible for successful delivery of what is offered in the proposal. The technology provider, his/her home institution, and any other organizations teamed on the proposal are considered the "proposers."

1. Who May Propose to the Terrestrial Planet Finder Technology Demonstration Mirror Technology Announcement (TA).

   This TA is restricted to U.S. qualified proposers. Qualified proposers are U.S. organizations including educational institutions, nonprofit nonacademic organizations, industry, NASA Centers including the Jet Propulsion Laboratory (JPL), and other government agencies. Within the bounds of all applicable federal regulations, there are no restrictions on the use of non-U.S. subcontractors or vendors for off-the-shelf components. However, non-U.S. sources for technology development would be counter to the objectives of the technology demonstration envisioned in this TA.

   In accordance with Federal statutes and NASA policy, no eligible applicant shall be excluded from participation in, denied the benefits for, or be subjected to discrimination under any program or activity receiving financial assistance from NASA on the grounds of race, color, creed, age, sex, national origin, or disability.

   In order to determine the appropriate funding instrument in the event a proposal is selected for funding, one of the categories listed below shall be indicated on the appropriate line on the proposal cover page.

   Types of Proposing Institutions:

   ***Educational Institution*:** An accredited university or college to confer degrees (all such institutions are considered nonprofit).

   ***Nonprofit, Nonacademic Organization*:** A private or Government supported research laboratory, university consortium, museum, observatory, or similar organization that supports advanced research but whose central charter is not for training students.

   Industry: An organization of any size that operates for profit on a fee basis with capabilities and interests to conduct advanced technology development

   ***NASA Center*:** Any NASA Center organization including JPL

   ***Other Government Agency*:** Any non-NASA, U.S. Federal Executive agency, national laboratory, or Federally Funded Research and Development Center (FFRDC) sponsored by a Federal Agency.

2. A Notice of Intent (NOI) to propose is requested. The NOI is neither a commitment to submit a proposal nor is information contained therein considered binding on the submitter. NOI's may be submitted by providing the information below to the "General Point of Contract" for this TA, Mr. William D. Kert, e-mail william.d.kert@jpl.nasa.gov
   - Reference to the TDM TA;
   - Technology Provider name, mailing address, phone number, and e-mail address;
   - Name(s) of institution(s) and any partnering organizations, if known by NOI due date;
   - Descriptive title of the technology
3. Proposers are requested to provide proposals that conform to the proposal content outlined in Appendix C.2. The right to make awards without discussion is reserved; therefore, proposals should be as complete as possible and submitted on the proposers' most favorable terms.
4. All responses received will be reviewed for applicability and appropriateness to the TA criteria; however, it is understood that there is no commitment implied or otherwise that peer reviews will result in a procurement. Neither the Government nor JPL will be responsible for any cost incurred in furnishing this information.
5. To be considered for award, a proposal shall, at a minimum, describe an advanced technology demonstration mirror that addresses the technology needs described in Appendix A. An organization may submit proposals for more than one technology concept. Proposals should contain sufficient technical information to permit a meaningful evaluation, using the defined evaluation criteria, and be signed by an official authorized to legally bind the technology provider's institution.
6. Joint Proposals: Where multiple organizations are involved, only one of them may submit the proposal. The proposal should describe the role to be played by the other organizations and indicate the legal and managerial arrangements contemplated.
7. Cooperative/shared development (i.e., cost sharing with other activities/organizations) is permitted. If such arrangements exist, attach confirmation letters from a person with the authority to commit the organization to the arrangement (not included in the page count).
8. Questions from potential respondents and answers from TPF will be posted on the following website: http://acquisition.jpl.nasa.gov/rfp/tdm/
9. Contract Type and Funding: For organizations requiring contracts for funding, the TPF will fund the Study Phase through fixed-price R&D, Cost Reimbursement with Educational Institutions (CREI) for universities contracts, issued by the Jet Propulsion Laboratory (JPL)/ California Institute of Technology. Proposers that require JPL to issue a Study Phase contract shall comply with JPL's General Provisions (GPs) and Additional General Provisions (AGPs). These GPs/AGPs are available through the Internet at http://acquisition.jpl.nasa.gov/e2000.htm. If you have an access problem or, would like to receive a copy of a specimen contract you may send a message to Mr. William D. Kert, e-mail william.d.kert@jpl.nasa.gov or call (818) 354-2992.

   After completion of the Study Phase and technology down-selection, the selected technology provider's organization will be invited to negotiate a new funding contract (or other agreement).

A proposal containing a large number of exceptions or one or more significant exceptions to the General Provisions and/or Additional General Provisions may make the proposal unacceptable for evaluation. Proposers must provide a detailed explanation, including the rationale, for any exceptions taken. Proposals containing exceptions may be selected for negotiations. However, if an agreement cannot be negotiated, the proposal may be rejected.

10. Other Agreements and Funding: For NASA centers and other government agency organizations, the TPF Office will establish written memoranda of agreements and administer a funds transfer through NASA Headquarters to the performing organizations.

11. Proposal Personnel: Each organization submitting a proposal shall designate a single "Key Personnel" Technology Provider who will lead the quality, direction, and content of the entire proposed effort through all phases, and for the use of all awarded funds. A key personnel / facilities clause similar to the one below will be required in the contract.

> The personnel and facilities specified are considered essential to the work being performed hereunder. Prior to removing, replacing, or diverting any of the specified individuals or facilities, the Contractor shall notify JPL reasonably in advance and shall submit justification (including proposed substitutions) in sufficient detail to permit evaluation of the impact on this Contract. No diversion shall be made by the Contractor without the written consent of JPL; provided, that JPL may ratify in writing the change, and such ratification shall constitute the consent of JPL required by this Article. With the consent of the Contracting parties, this clause can be amended from time to time during the course of the Contract to either add or delete personnel and/or facilities as appropriate.

12. Proposal Delivery: Proposals may be mailed or hand delivered to the addresses in the TA. For hand carried proposals, the JPL Visitor Control Center is open to receive proposals only on working weekdays, between 7:30 a.m. and 4:30 p.m. The JPL Visitor Control Center will date and time stamp your proposal. Proposals are due at the time and date stated on the cover of this TA.

13. Late Proposals: Any proposal, portion of the proposal, or unrequested proposal revision received at JPL after the time and date specified on the cover page of the TA is late. Any volume of a proposal received after the time and date specified will cause the entire proposal to be late. Processing delays at the proposer's home institution or its methods of shipping do not excuse the late submission of a proposal. Late proposals will not be considered for award, except under the following circumstances:

    - JPL determines that the late receipt was due solely to a delay by the U.S. postal service for which the offeror was not responsible. Timely postmark or receipt of registered, certified, or express mail "next–day service," establishing the time of deposit, shall be evidenced.
    - JPL determines that the proposal was late due solely to mishandling by JPL after receipt at JPL, provided that the timely receipt at JPL is evidenced.
    - No acceptable proposals are received in a timely manner.

14. Withdrawal: Proposers may withdraw proposals at any time before award.

15. Proposals should not contain security classified information or depend on access or use of security classified information or classified facilities for any portion of the activities.

B.2 PROPOSAL INFORMATION DISCLOSURE

Restriction on Use and Disclosure of Proposal Information. If a proposal contains proprietary information that should not be used/disclosed for any purpose other than proposal evaluation, it should be clearly marked by placing the following legend on the proposal response cover sheet:

NOTICE
"The information (data) contained in [insert page numbers or other identification] of this proposal constitutes a trade secret and/or information that is commercial or financial and confidential or privileged. It is furnished to the Government and the Jet Propulsion Laboratory/California Institute of Technology ("Institute") in confidence with the understanding that it will not, without permission of the proposer, be used or disclosed other than for evaluation purposes; provided, however, that in the event a contract (or other agreement) is awarded on the basis of this proposal, the Government or the Institute shall have the right to use and disclose this information (data) to the extent provided in the contract (or other agreement). This restriction does not limit the Government's or Institute's right to use or disclose this information (data) if obtained from another source without restriction."

B.3 PAGE LIMITS

Responses are limited to 20 pages (including figures, see Table B.3). Proposals that contain information exceeding the page limit will have the excess pages removed, and the excess pages will not be evaluated. Proposal format shall be as follows:

- Typewritten using easily readable 12 point type fonts on white 8.5x11 inch paper, in single or double columns with at least a 1 inch margin on all sides;
- Double-sided printing preferred but not required (each side counts as one page);
- Bound only with metal staples (no cardboard or plastic covers, or permanent binders);
- An easily disassembled original (to enable making additional copies if needed);
- No fold out pages;
- No material submitted on electronic media, nor reference on websites needed to complete the evaluation;
- Use only metric units in the body of the proposal; and
- Strictly adhere to the page limits as follows:

Section	Page Limits
Cover Page	Not Counted
Proposal Summary	1
Table of Contents	Not Counted
Technical/Management	18
Proposed Personnel / Resumes	Not Counted
Facilities and Equipment (as needed)	1
Current and Pending Support	Not Counted
Proposed Study Phase Cost	Not Counted
Proposed Study Phase Schedule	Not Counted
Estimated Demonstration Phase Cost	Not Counted
Estimated Demonstration Phase Schedule	Not Counted
Past Performance	Not Counted
References (can be a separate attachment / file)	Not Counted

Table B.3 Proposal Page Limits

B.4 NOTIFICATION

JPL will notify all proposers of their selection or non-selection.

B.5 CONTRACT (OR OTHER AGREEMENT) NEGOTIATIONS AND AWARD

When the funding instrument is a contract, a JPL acquisition representative will handle negotiations, funding, and contract execution. The proposal for the Study Phase and the resulting Study Phase Final Report will be used as the basis for negotiations. The procurement representative may request certain business data through the Technology Provider's business office and may forward a specimen contract and other information pertinent to negotiations. When the funding instrument is not a JPL contract, NASA Headquarters will handle an "other agreement" process for transferring funds to the technology providers' organization. In all cases, awards will be made to institutions, not directly to the Technology Provider.

B.6 CANCELLATION

NASA and JPL reserve the right to make no awards under this TA and to cancel this TA. NASA and JPL assume no liability for canceling the TA or for anyone's failure to receive notice of cancellation.

B.7 ATTACHMENTS

The following attachment to Appendix B includes essential information and supplemental instructions for proposal preparation.

a. Forms and Documents Containing Information Applicable To This TA.

ATTACHMENT B.7.a, FORMS AND DOCUMENTS CONTAINING INFORMATION APPLICABLE TO THIS TA.

The following attached forms and documents are organized into two major groupings:

1. Group A shall be completed and returned as part of your quotation or cost proposal.
2. Group B is for information purposes only in preparing your quotation/proposal.

Both A and B group attachment documents are available through the electronic address: http://acquisition.jpl.nasa.gov/e2000.htm Hard copies of the Group B documents will be mailed by request only. Note that Group B Attachments may become requirements under a JPL Contract.

NOTE TO PROPOSERS: *Only the forms and documents listed below marked* X *in the box preceding the Attachment Number are applicable.*

GROUP A – Complete and return as part of your quotation/cost proposal, as applicable:

	Attachment Number	Title and Form Number
X	A-1	Acknowledgment (form JPL 2384)
X	A-2	Cost Accounting Standards (form JPL 2842) (if over $500K)
X	A-3	Government Property Questionnaire (form JPL 0544) (if required)
	A-4	(RESERVED)
	A-5	(RESERVED)
	A-6	Notice of Total Small Business Set-Aside (form JPL 4022)
	A-7	Notice of Total Small Business Set-Aside – Modified (form JPL 4023)
	A-8	(RESERVED)
	A-9	(RESERVED)
	A-10	(RESERVED)
	A-11	(RESERVED)
	A-12	Foreign Acquisitions – Certification of Eligibility for Exemption from/Certain JPL General Provisions, Additional General Provisions, and Certifications (form JPL 2881)
	A-13	(RESERVED)
X	A-14	Past Performance (form JPL 0358)
X	A-15	Cost Element Breakdown (form JPL 0549)
	A-16	Determination of Lowest Overall Price - Time-and-Material Proposals (form JPL 0359)
	A-17	Determination of Lowest Overall Price - Labor Hour Proposals (form JPL 0363)
	A-18	Determination of Lowest Overall Price - Labor-Hour Proposals to JPL-Provided Rate Ranges (form JPL 0364)
X	A-19	Cost Elements Breakdown (Short Form) (form JPL 0549-1)

GROUP B – For information only:

Attachment Number		Title and Form Number
X	B-1	Waiver of Rights to Inventions (form JPL 62-301)
	B-2	Summary Work Breakdown Structure (no form number)
	B-3	Notice to Offerors (form JPL 2843)
	B-4	Instructions for Patent Agreement for Use in Support Service Contracts (form JPL 2844) Patent Agreement (form JPL 1929)
	B-5	Notice of Requirement of Pre-award On Site Equal Opportunity Compliance Review (form JPL 3553)
X	B-6	Requirements for A Subcontracting Plan (form JPL 0294), if applicable
	B-7	Security Requirements for a Classified Contract (form JPL 2891)
	B-8	Notice of Requirement for Affirmative Action to Ensure Equal Employment Opportunity (Executive Order 11246) (form JPL 2899)
	B-9	☐ Notice to Prospective Contractors of Requirement for an Environmental Audit of the Lease Facilities (form JPL 2896) ☐ Notice to Prospective Contractors of Requirement for an Environmental Audit of the Lease Facilities – Alternate (form JPL 2896-1)
X	B-10	Certificate of Current Cost or Pricing Data (form JPL 2496), if applicable
	B-11	Standards of Conduct and Procedures for Handling Contractor Personnel Problems, Discipline, and Separation (form JPL 4412)
	B-12	(RESERVED)
X	B-13	Claims for Exceptions to Cost or Pricing Data (form JPL 2703)
	B-14	Billing Instructions - Cost-Type Contract (form JPL 2716)
X	B-15	Billing Instructions - CREI Contract (form JPL 2717)
	B-16	Billing Instructions - Labor-Hour/Time-and-Material Contract (form JPL 2718)
	B-17	JPL Contractor Safety and Health Notification (form JPL 2885)

APPENDIX C

TDM Technology Concept Definition Study Phase
Specific Proposal Preparation Instructions

C.1 INTRODUCTION

Proposers are expected to provide sufficient details to enable evaluation by persons who are knowledgeable of, but not necessarily specialists in, the proposed technology. Proposals shall be self-contained. That is, no knowledge of technology outside of that described in the proposal should be assumed.

Key areas of the proposal include: (1) a sufficiently detailed description of the proposed technology concept and an explanation of the specific merit of the proposed technology demonstration mirror concept relative to the technology needs in Appendix A; (2) technology maturity information on the proposed technology concept and the proposed approach for substantiating the predicted performance; (3) a description of the proposed Study Phase activities and their associated cost and schedule; (4) a discussion of the proposed management approach, including the management structure and the system for tracking and reporting progress; and (5) information on the requisite experience and organizational capability for demonstration of the technology.

C.2 DETAILS OF PROPOSAL CONTENTS

All proposals should be assembled with the following parts and in the order listed:

1. Cover page that contains the following information:

    - Name of this TDM TA;
    - Date of submission;
    - A proposal title;
    - The legal name and address of the organization and specific division or campus identification, if part of a larger organization;
    - Point of contact, mailing address, telephone number, FAX number, and e-mail address of the business office person at the technology provider's sponsoring institution;
    - Proposing Technology Provider's name and full institutional mailing address, telephone number, FAX number and e-mail address;
    - Technology Provider signature and date;
    - The institutional endorsement, which requires the name and title of the authorizing institutional office, the full legal name of the proposing institution, signature of the authorizing individual, and date;
    - Designation of the proposing institution type using the definitions in Appendix B.

2. Proposal Summary

   - A statement summarizing the potential capability of the proposed technology concept to satisfy the technology needs described in Appendix A.
   - A brief description of the proposed technology demonstration mirror concept that summarizes its central features and predicted performance, and the proposed demonstration goals using terminology understandable to a non-specialist, and a concise statement of the proposed approach for demonstrating technology maturity.
   - Pictorial material for the proposed technology that is suitable for public release

   NASA or JPL may publish the proposal title, the Technology Provider's name and institution, summary description, and picture (or drawing) of all selected technology concepts in a public forum. Therefore, the Proposal Summary should not include proprietary information that would preclude its unrestricted release.

3. Table of Contents

4. Technical and Management Section

   a. Technical Approach

      The most important aspect of the proposal is the capability of the technology to meet the needs of TPF contained in Appendix A. Accordingly, proposers should fully describe their technology demonstration mirror concept and Study Phase activities so that reviewers can assess both the potential capabilities of the concept, and the likelihood for demonstrating its performance with a hardware deliverable by the end of the Demonstration Phase. Therefore, the technical section should include the following:

      - A summary description of the proposed technology demonstration mirror concept, including;
        - Conceptual layout of the proposed technology demonstration mirror
        - Predicted optical performance, and a discussion of how it has been calculated. Any applicable relevant test results shall be discussed. Describe the best mid-spatial wavelength performance achieved to date and the type of optic (e.g., diameter, on- or off-axis, f/#, etc.) on which this performance was achieved. Explain the proposed approach for improving performance in the mid-spatial wavelength range.
        - Discussion of how the TDM optical characteristics / performance will be measured / verified including analysis, metrology, and test equipment, and the limitations of the proposed measurement / verification approach. Discuss the best accuracy achieved to date in the three spatial wavelength ranges specified in Appendix A. Summarize the technique used to obtain these results, and what is proposed to achieve the level of metrology required to measure the TDM.
        - Discussion of materials selection and fabrication processes planned
        - Physical characteristics such as size and mass properties for the technology demonstration mirror, and how they will be verified

- Discussion of the coating application technique to achieve the required spatial uniformity of the reflectivity and the technique proposed to measure this uniformity.

- Discussion of changes suggested or exceptions requested to the TDM Detailed Equipment Specifications in Appendix A, or deviations from the baseline configuration described therein, and the implications of bringing the proposed technology demonstration mirror into compliance with those specifications;
- Description of the technical merit of the proposed technology relative to the needs of TPF. Discuss the potential for making larger sizes and different / non circular shapes, and associated needs for building new facilities or equipment;
- Potential of the proposed technology to benefit a TPF precursor mission;
- Description of the current maturity of the proposed technology (in particular reduction of the mid-spatial frequency errors, metrology, and relative coating uniformity) and the technology maturity level expected at the end of the Study Phase. Explain how these determinations were derived;
- Discussion of the significant technical challenges to be overcome;
- Discussion of the TDM demonstration approach to substantiate the predicted performance including major technical milestones and any special materials, parts or processes needed, including how the TDM would be qualified for space flight;
- Description of proposed Study Phase activities and their associated cost and schedule (put all cost and schedule information in the "Cost and Schedule" Section, and use pointers to direct the reader to the location in the Cost and Schedule Section where details associated with the activity are provided, i.e., "the cost details for test #3 to demonstrate technical maturity are in section 9.a.b.c, and the schedule details are in section 9.x.y.z". Make the linkage clear between cost, schedule, and activity/result/deliverable).

b. Management Approach

This section shall summarize the management approach and the facilities and equipment required. The management approach should describe essential management functions, and the overall integration of these functions to assure adequate control of the proposed effort within the cost and schedule constraints. This section shall provide insight into the organizations proposed to do the work, including the internal operations and lines of authority, together with internal interfaces and relationships with NASA, any team members, major subcontractors, and associated collaborators. It also identifies the institutional commitment of all team members, and the institutional roles and responsibilities. Proposers shall define the management approach and tools for controlling cost and schedule best suited for their particular teaming arrangement. Proposers should also have a Work Breakdown Structure (WBS) that best fits its organizational approach and technical capabilities of all team members. The use of innovative processes, techniques, and activities to accomplish their plans is encouraged if cost, schedule, and technical improvements can be demonstrated.

Proposals that include teaming arrangements, partnering and/or contributions to meet the technology demonstration objectives shall specifically address how the proposed team will interrelate internally and with NASA, both organizationally and managerially.

The management section should include the following:

- Approach for managing Study Phase activities including the work breakdown structure, a schedule, and the proposed organizational structure;
- Identify the roles and responsibilities for each participating organization and key individuals for the proposed effort including their level of support for the duration of the Study and Demonstration Phases;
- A discussion of the capabilities each participating organization brings to the proposed effort, and relevant experience with similar systems and equipment;
- Approach for securing any proposed collaborations
- Assumed funding contributions by technology demonstration collaborations or partnering arrangements with other individuals or organizations not included in the proposed funding;
- If applicable, the plan for managing the distribution of responsibilities and arrangements for ensuring a coordinated team effort capable of effectively carrying out the proposed technology study / demonstration activity;
- Basis and justification for the cost and schedule estimates for Study Phase and Demonstration Phase activities, including letters of commitment from critical suppliers and/or cost / resource sharing contributors;
- Approach for managing cost and schedule risk for all activities with emphasis on the blank procurement, required metrology accuracy, ability to achieve low mid-spatial frequency errors, and the ability to coat the TDM to the specified spatial uniformity;
- Expected contribution/commitment by the Technology Provider and his/her parent organization to the proposed technology demonstration effort (include cost and resource sharing, partnering arrangements, etc.);
- Technology Provider's historical experience, performance, and institutional capability in the area of technology demonstration and subsequent application.

5. Proposed Personnel. Submit a one-page resume for each of the key personnel who will support the proposed effort (not included in page count).

6. Facilities and Equipment. This section should describe any facilities (including any U.S. Government owned facilities) and/or test or fabrication equipment that are critical for carrying out the proposed Study Phase. Discuss the availability of these special facilities and equipment items and any additional equipment or facilities that will be required. Costs for using these facilities shall be included in the proposal Budget Summary. Provide written substantiation (not included in the page count) from the government or other source showing concurrence with the proposed use.

7. Current and Pending Support. Briefly describe any current or planned sources of support that will be contributing to the proposed TDM activity. Identify the ongoing and pending projects, sponsoring organization, relevance to the proposed technology, and the resources each organization will contribute or share (not included in page count).

8. Copy of References. All referenced papers cited in the proposal shall be provided as an attachment to the proposal. For book citations, provide a copy of the relevant pages and the full title of the book and/or an easily understood abbreviation of the publication (e.g., library standard citation or AIAA format) (the copies of reference papers and book references are not included in the proposal page count).

9. Proposed Cost and Schedule.

    a. Proposed Study Phase Cost: Provide a one-page cost summary indicating the funding requirements for the Study Phase. Provide an explanation of the proposed funding arrangements. Possibilities include: TPF funds all study costs; proposer shares study costs with TPF; or proposer funds all study costs.

       The Study Phase Cost Proposal shall be submitted per the requirements of the TDM Study Phase Statement of Work and Delivery Schedule (refer to Appendix C.4.a)

    b. Proposed Study Phase Schedule: Provide a detailed schedule of the proposed Study Phase activities leading to delivery of the Study Phase Final Report.

    c. Estimated Demonstration Phase Cost: Provide a one-page cost summary indicating the anticipated funding requirements for the Demonstration Phase. This non-binding ROM estimate when combined with the Study Phase cost should reflect the total estimated cost to demonstrate the capabilities and performance of the proposed technology concept. Provide an explanation of the proposed funding arrangements.

    d. Estimated Demonstration Phase Schedule: Provide a one-page preliminary schedule for Demonstration Phase activities that identifies the major milestones leading to delivery of the Technology Demonstration Mirror.

10. Past performance. Discuss relevant experience and past performance (successes and failures) of the proposers in meeting cost and schedule constraints for similar technology study and demonstration activities within the last five years. Provide a description of each project, its relevance to the proposed TDM deliverable, cost and schedule performance, and points of contact (including addresses and phone numbers).

C.3 PROPOSAL EVALUATION CRITERIA

Listed below are the principal criteria and their relative importance for evaluating technology demonstration mirror concepts for Study Phase selection. Within each criterion, factors are of roughly equal importance.

T1 - Technical Merit and Benefits to TPF (30%): Evidence of technical merit, and feasibility of the Technology Demonstration Mirror concept to meet the needs of TPF and potential precursor missions. Factors to be considered are:

A. Potential for providing the capabilities, and achieving the performance requirements described in Appendix A.
B. Relevance, value, and benefits of the proposed Technology Demonstration Mirror concept toward meeting TPF needs.
C. Degree to which a TPF precursor mission can use the proposed technology.

T2 - Technology Maturation (30%): Credibility of the proposed technology demonstration plan and the soundness of the approach for substantiating the predicted performance. Factors to be considered are:

A. Current maturity of the proposed Technology Demonstration Mirror technology and strength of the evidence to show how this maturity has been derived or verified.
B. Soundness of the proposed technical approach to assure successful completion of the Study and Demonstration Phases.
C. Adequacy of the testing planned to demonstrate that the TDM has achieved the required performance at the completion of the Demonstration Phase.

M1 - Management and Implementation Approach (40%): Thoroughness and credibility of the proposed approach to implementation, including the management structure, schedule realism, level of detail and basis of cost estimate. Factors to be considered are:

A. Effectiveness of the organizational structure to carry out the proposed management plan for the end-to-end design, fabrication, and demonstration effort, including identification and availability of key personnel.
B. Effectiveness of the proposed management plan to structure relationships between different elements of the proposer's team that provide funding support such that a single management voice exercises decision authority.
C. Realism and reasonableness of the proposed cost, including contribution assumptions, to complete all design, fabrication, and demonstration activities.
D. Realism and reasonableness of the proposed schedule for design, fabrication, and demonstration activities, and the effectiveness of the system for tracking progress.
E. Experience of the Technology Provider and organizational capability to deliver the technology demonstration mirror.
F. Past performance for similar technology demonstration and subsequent application.
G. Commitment of the organization's management to the proposed technology effort.

C.4 ATTACHMENTS

The following Appendix C Attachments include essential information and supplemental instructions for proposal preparation.

a. TDM Study Phase Statement of Work and Delivery Schedule

ATTACHMENT C.4.a TDM STUDY PHASE STATEMENT OF WORK AND DELIVERY SCHEDULE

STATEMENT OF WORK AND DELIVERY INSTRUCTIONS

1.0 TDM Study Phase awardees shall conduct a Technology Concept Definition Study Phase ("Study Phase"), and complete the preliminary design of a technology demonstration mirror that complies with the TDM Detailed Equipment Specification in Appendix A. The technology demonstration mirror preliminary design shall be presented at a review to be held at JPL, and documented in a Study Phase Final Report, per the instructions in Appendix E.

2.0 Schedule of Deliverables:

Deliverable	Schedule	Description (see paragraphs below for details)
Kickoff meeting	2 weeks ARO*	At contractor's site; introduce key personnel, discuss planning for Study Phase
Weekly Progress Reports	Weekly	Telecon / e-mail discussion of progress, overall status, issues, problems, and proposed solutions
Mid-Term Study Phase Progress Review	6 weeks ARO	At contractor's site, review initial TDM design, fabrication, and demonstration plans
Preliminary Design Review	11 weeks ARO	At JPL, design presentation to user community on proposed technology demonstration mirror
Study Phase Final Report	13 weeks ARO	Detailed description of the preliminary design for a TDM, and Demonstration Phase technical, management, and cost plans

** ARO – After Receipt of Order*

2.1 Kickoff meeting

A kickoff meeting will be held at the contractor's site to introduce key personnel, and discuss establishing management and contract relationships.

2.2 Weekly Progress Reports

Study Phase awardees shall provide weekly teleconference and electronic progress / status reports to review overall progress, status, issues, problems, and proposed solutions.

2.3 Mid-Term Study Phase Progress Review

A Mid-term Study Report (in a common electronic form) and oral presentation at the contractor's site shall be provided to review the initial TDM design, and corresponding preliminary fabrication and demonstration plans.

2.4 Preliminary Design Review (PDR)

The Preliminary Design Review shall be held at JPL as a forum open to the TPF science and engineering communities, with the intent of providing the broadest possible dissemination of information, and discussion of system-level issues associated with the proposed technology demonstration mirror. The presentation shall cover the material required for the Study Phase Final Report.

2.5 Study Phase Final Report

Technology Providers shall deliver a Study Phase Final Report per the instructions given in Appendix E. The complete three volumes Study Phase Final Report will constitute the Technology Providers' Demonstration Phase proposal. As such this report shall fully describe the following:

2.5.1 The proposed technology demonstration mirror preliminary design (i.e. specifically what is to be built and how well it is predicted to meet the requirements listed in Appendix A);

2.5.2 The Demonstration Phase Technical Plan for completing the technology demonstration mirror design, and building and testing it to assess the technology's capabilities and potential performance; and

2.5.3 A Demonstration Phase Management And Cost Plan that clearly explains what is required to successfully implement the Demonstration Phase Technical Plan.

APPENDIX D

Process for Technology Concept Selection

D.1 EVALUATION AND SELECTION PROCESS

A technical peer review process will be used to evaluate proposed technology concepts for the TDM Study Phase and again later to evaluate Study Phase Final Reports for down-selecting technology concepts for the Demonstration Phase.

All proposals will initially be screened to determine their suitability and responsiveness to the TA. Proposals that are not in compliance with the constraints, requirements, and guidelines of this TA will be handled as technical correspondence and returned to the proposer without further review. Those proposals deemed responsive to the TA will then be reviewed to determine if any government, national laboratory, or FFRDC response duplicates and directly competes with a response from industry, a university or a nonprofit organization. If such a situation exists, the government, national laboratory, or FFRDC proposal will not be evaluated and will be returned to the originator.

After the screening process, proposals will be reviewed by a panel composed of the technology provider's professional peers, who will evaluate the strengths and weaknesses of the technical and management information provided. The peer review panel will develop findings, and a final consensus evaluation and selection recommendation for each proposal. This information will be provided to the NASA HQ executive who will select technology concepts for TPF funding. JPL will provide notice of selections and make awards.

In the Study Phase, each technology provider will be required to produce a detailed Study Phase Final Report that fully describes their technology demonstration mirror concept, and the plan to demonstrate its potential capabilities and performance in the TDM Demonstration Phase. At the end of the study phase, technology providers will present their mirror design and demonstration plan at a Preliminary Design Review (PDR). The PDR and accompanying Study Phase Final Report that includes a cost and management volume as described in Appendix E, will serve as the primary basis for approval to proceed to the TDM Demonstration Phase. The review and selection processes used for Study Phase proposal evaluations will be repeated for evaluating Study Phase Final Reports and down-selection to the Demonstration Phase. Candidates for the Demonstration Phase will be limited to technology providers that provide a TDM Study Phase Final Report.

D.2 SCHEDULE

Study Phase Proposals Due	Date specified in TA
Study Phase Selections Announced	+6 wks after above
Study Phase Final Reports Due	+3 mo after above
Demonstration Phase Selections Announced	+4 wks after above

APPENDIX E

TPF Technology Demonstration Mirror Study Phase Final Report Instructions

E.1 TDM Study Phase Final Report Content Instructions

The primary output from the TDM Study Phase will be a final report that describes the TDM technology concept and the plan to build and test a TDM for the assessment of the technology's capabilities and potential performance.

The TDM Study Phase Final Report shall have three volumes: (1) Technology Demonstration Mirror Detailed Preliminary Design, (2) Demonstration Phase Technical Plan, and (3) Demonstration Phase Management and Cost Plan. The TDM preliminary design and Demonstration Phase technical plan volumes shall be non-proprietary and available to TPF and other NASA science and engineering communities to allow the broadest possible discussion of system-level issues associated with using the proposed technology concept in a TPF precursor mission. Proprietary data may be presented separately, and shall be handled in accordance with the terms and conditions of the study contract (or agreement).

1.0 Technology Demonstration Mirror Detailed Preliminary Design Volume Contents

The detailed preliminary design volume shall fully describe the design of the TDM concept including information such as the following:

1.1. The TDM Preliminary Design shall include at a minimum:

- 1.1.1. TDM design assumptions and design margins discussion.
- 1.1.2. Layout drawings of major subassemblies.
- 1.1.3. Predicted optical performance and a discussion of how it has been calculated. Any applicable measurement / test results shall be discussed. Especially important is the understanding of mid-spatial frequency characteristics and how they are affected by:
  - 1.1.3.1. The function and interfaces of the TDM in a telescope system;
  - 1.1.3.2. Fabrication methods for a steep aspheric on a lightweight substrate;
  - 1.1.3.3. Measurement methods and their characteristics / limitations;
  - 1.1.3.4. Mechanical factors that perturb the surface at these frequencies, and the substrate and mount that will be needed to control these factors;
  - 1.1.3.5. Coating methods to achieve uniform reflectance, and evaluative methods to assure the uniformity of reflectance.
- 1.1.4. Optical figure error analysis / budget, for zero and one g environments.
- 1.1.5. Properties of material selected for the TDM.
- 1.1.6. Design and process for lightweighting the TDM.
- 1.1.7. Design of handling fixture for blank.
- 1.1.8. Design of support for mirror during grinding and polishing.
- 1.1.9. Technique to deal with core print through.

1.1.10. Design of the pads, flexure, and strongback to support the TDM.
1.1.11. Structural model of the TDM assembly (this includes mounting pads and flexures) showing physical layout, mass properties, modal frequencies below 500Hz, and static loads that can be sustained before fracture or deformation beyond what is allowed in the TDM Detailed Equipment Specifications.
1.1.12. Cell hole design for depressurization in the launch shroud.
1.1.13. Thermal model of the TDM.
1.1.14. Gravity off-load analysis for global and core cell sag.
1.1.15. Technique to deal with gravity when fabricating and measuring a mirror in one g that will operate in zero g.
1.1.16. Metrology technique and error analysis to include the estimated residual errors due to gravity, air turbulence, temperature variations, vibrations, sampling, and instrumentation.
1.1.17. Discussion of the coating methodology and the technique that will be used to measure the reflectivity variation and the estimated errors in this technique.
1.1.18. Precautions to control contamination on the coated TDM.
1.1.19. Design of the shipping container.
1.1.20. Identification of any space environment sensitivity concerns, major open design and demonstration issues, trade studies, problems, and plans for their resolution in the Demonstration Phase.

1.2. System Tradeoffs

Describe the TDM design trade-offs and alternative concepts that were examined in sufficient detail to explain why the selected design is preferred. At a minimum discuss the following trade-offs:

1.2.1. Material selection
1.2.2. Blank lightweighting process
1.2.3. Structural design of the TDM
1.2.4. Position of mounting points
1.2.5. Positioning of fiducials
1.2.6. Gravity off-load technique
1.2.7. Metrology technique selection
1.2.8. Coating process and measurement technique

Discuss the potential for utilizing the selected design and fabrication processes to fabricate apertures that are not symmetric and/or have non-smooth boundaries (e.g. square, hexagonal, and elliptical, mirrors). Describe and quantify the impacts of going to (a) larger sizes, and (b) lower areal densities.

1.3. Recommended Changes to the TDM Detailed Equipment Specifications

Provide recommended TDM Detailed Equipment Specifications revisions, augmentations, or updates for deliverables under this contract. Include rationale for your recommendations.

2.0 Demonstration Phase Technical Plan Volume Contents

The TDM Demonstration Phase will encompass the detailed design, fabrication, test and evaluation, and delivery of the proposed Technology Demonstration Mirror. The TDM Demonstration Phase Technical Plan volume shall include the following:

2.1. A Statement of Work including all deliverables for the Demonstration Phase.

2.2. Technology Demonstration Mirror Final Design and Fabrication Plan

Describe the steps planned to complete the Technology Demonstration Mirror design and fabrication, and associated ground support equipment. Discuss the approach for acquiring / fabricating, integrating, and testing the hardware deliverables, including all ground support equipment. Provide a description of the main processes/procedures planned for design validation and hardware manufacture, including testing strategy.

Provide a preliminary version of the manufacturing plan document describing the end-to-end procedure for TDM design and fabrication.

Also discuss the plan and associated safety and product assurance processes and procedures for handling, moving, and shipping the Technology Demonstration Mirror.

2.3. Technology Demonstration Mirror Test and Verification Program

Appendix A.4.a, the TDM Detailed Equipment Specifications, lists the major analysis, measurements, and tests required to characterize the TDM (refer to the TDM verification matrix). The approach for completing these analysis, measurements, and tests and obtaining the data shall be described. The individual cost for each major analysis, measurement, and test shall be provided in the Demonstration Phase management and cost plan volume.

Also provide a separate costed option for completing a program of protoflight qualification testing of the TDM before delivery. Include a detailed milestone schedule.

Any facilities which must be built for this program shall be identified, along with the facility design and/or construction schedule necessary to meet the TDM delivery schedule.

2.4. Schedule

A detailed schedule of design, fabrication and test, and verification activities shall be provided that identifies the major technical milestones leading to the delivery of the Technology Demonstration Mirror.

3.0 Demonstration Phase Management and Cost Plan Volume Contents

The TDM Study Report Demonstration Phase Management and Cost Plan volume shall describe the management approach, tools and processes that will be used to complete the TDM technology concept demonstration, within the proposed cost and schedule.

3.1. Organizational Structure

Describe the organizational structure proposed to carry out the Demonstration Phase activity. Identify the organizational roles, authority, and responsibilities of each participating organization. Provide insight into each organizational element's internal operations and lines of authority, together with internal interfaces and relationships with NASA, any team members, major subcontractors, and associated collaborators / partners.

Identify the specific decision-making processes to be used, and the individual with ultimate decision-making authority. Specifically, include the applicable capabilities that each partner or proposed partnering organization expects to contribute. Identify key personnel in each organization and the level of support they will provide for the duration of the Demonstration Phase. Describe the distribution of responsibilities and arrangements for ensuring a coordinated team effort capable of effectively managing the Demonstration Phase activity.

Include a discussion of the unique or proprietary capabilities that each member organization brings to the activity. The contractual and financial relationships between partners should be discussed. Summarize the relevant institutional experience and organizational capability with reference to supporting what is offered in any letters of endorsement.

3.2. Resource Management Methods and Tools

Describe the methods and tools that will be used for tracking progress towards technical milestones, and for tracking / assessing cost and schedule status. Provide a description of the Work Breakdown Structure (WBS) and how it best fits its organizational approach and technology demonstration capabilities of all team members. A sample WBS is provided in Appendix E.4.b.

Provide information on procurement of long lead items and proposed major and critical subcontracts, including procurement activities of all team partners. Describe the relationships and controls that will be exercised over suppliers and subcontractors from both cost and schedule standpoints.

3.3. Risk Management

Describe the plans for risk management, and the approach for identifying and mitigating technical performance, schedule, and cost risks. Particular emphasis shall be placed on describing how the various elements of risk will be managed to ensure successful accomplishment of the demonstration phase within the proposed cost and schedule.

3.4. Product Assurance and Safety

Describe the plans to ensure product quality, including specific reviews, trade studies, plans to incorporate new technologies, inspections, and quality assurance activities.

In addition, describe the process by which safety standards are met and hazards mitigated.

3.5. Cost Estimate, and Funding Assumptions and Requirements

Identify the funding required to implement the Demonstration Phase Technical Plan. Provide an explanation of the proposed funding arrangements including:

3.5.1. Provide a cost summary of the proposed funding requirements for the Demonstration Phase indicating the funding required from TPF and any cost sharing arrangements;

3.5.2. Describe any assumed funding contributions by collaborations or partnering arrangements with other individuals or organizations not included in the proposed TDM funding;

3.5.3. Basis and justification for the cost and schedule estimates for Demonstration Phase activities, including letters of commitment from critical suppliers and/or cost / resource sharing contributors;

3.5.4. Expected contribution/commitment by the Technology Provider and his/her parent organization to the proposed technology demonstration effort (include cost and resource sharing, partnering arrangements, etc.);

3.5.5. Current and Pending Support. Briefly describe any current or planned sources of support that will be contributing to the proposed technology activity. Identify the ongoing and pending projects, sponsoring organization, relevance to the proposed technology, and the resources each organization will contribute or share (not included in page count).

The Demonstration Phase Cost Plan shall be submitted per the requirements in Appendix E.4.c, for the TDM Technology Demonstration Phase Statement of Work and Delivery Schedule in Appendix E.4.a.

3.6. Furnished* Property, Services, Demonstration Facilities, etc.

This section shall delineate the property, services, technology demonstration facilities, etc. to be furnished by the Government or a commercial source, if any, which will be required to accomplish all proposed Demonstration Phase activities. Discuss the availability of these special facilities and equipment items and any additional equipment or facilities that will be required. Costs shall be included in the proposal Budget Summary. Provide written substantiation from the government or other source showing concurrence with the proposed use. This could be an approval letter from the cognizant government contracting officer or an equivalent commercial agent for the use of the property, service, or facilities.

*(*Provided by other than subcontract or purchase order)*

3.7. Reporting and Reviews

Describe the approach planned for reporting technical status / progress. Also, discuss the methods of reporting integrated cost, schedule, and technical performance. Identify the individual or organization function responsible for reporting.

3.8. Plans to Resolve Open Management Issues

Identify and discuss any unresolved issues. Include the planned approach and schedule for resolving these issues.

E.2 TDM STUDY PHASE FINAL REPORT SUBMISSION INSTRUCTIONS

The TDM Study Phase Final Report will constitute the technology providers' Demonstration Phase proposal. This section provides guidelines for the preparation and submittal of the Study Phase Final Report and required supporting information.

a. Certification - The original copy of the Study Phase Final Report shall be accompanied by a Letter of Commitment signed by an official of the providing organization. This official shall certify institutional support and sponsorship for the technology concept, its technical demonstration plan, and the associated management and financial proposal.

b. Quantity & Address - Fifteen (15) copies of the Study Phase final report shall be submitted to the following address:

   Mr. William D. Kert
   Jet Propulsion Laboratory
   4800 Oak Grove Drive, M/S 190-220
   Pasadena, California 91109-8099

c. All Study Phase material shall arrive at JPL by 3:00 p.m. local time before November 27, 2002

E.3 TDM STUDY PHASE FINAL REPORT EVALUATION CRITERIA

The criteria below and degree of importance will be used for Demonstration Phase proposal evaluation.

Technical Criteria

T1 - Technical Merit And Benefits To TPF (30%): Evidence of technical merit, and feasibility of TDM concept to meet the needs of TPF. Factors to be considered are:

A. Thoroughness and completeness of the TDM preliminary design and documentation.
B. Potential for providing the capabilities, and achieving the performance requirements described in Appendix A.
C. Degree to which a TPF precursor mission can use the proposed technology.

T2 - Technology Maturation (30%): Credibility of the proposed technology demonstration plan and the soundness of the approach for substantiating the predicted performance. Factors to be considered are:

A. Current maturity of the proposed TDM technology and strength of the evidence to show how this maturity has been derived or verified.
B. Soundness of the proposed technical approach to assure successful completion of the Demonstration Phase objectives.
C. Adequacy of the testing planned to demonstrate that the TDM has achieved the required performance at the completion of the Demonstration Phase.

Management Criteria

M1 - Management and Implementation Approach (40%): Thoroughness and credibility of the proposed technology demonstration plan, including the management structure, schedule realism, level of detail and basis of cost estimate, the requisite experience and organizational capability and commitment to deliver the proposed technology concept. Factors to be considered are:

A. Effectiveness of the organizational structure to carry out the proposed management plan for the demonstration effort, including identification and availability of key personnel and their level of support to the Demonstration Phase activity.
B. Effectiveness of the proposed management plan to structure relationships between different elements of the proposer's team that provide funding support such that a single management voice exercises decision authority.
C. Realism and reasonableness of the proposed cost, including contribution assumptions, to successfully complete all demonstration activities.
D. Realism and reasonableness of the proposed schedule for demonstration activities, and the effectiveness of the system for tracking progress.
E. Efficacy of the approach for identifying and managing significant risks, including the associated mitigation approaches and descope options.
F. Past performance on similar technology demonstration and subsequent application.
G. Commitment of the organization's management to the proposed technology effort.

Proposals will be evaluated in the areas of technical and management as described above. Although cost will not be scored, cost is a substantial consideration and is of approximately equal importance to the technical and management areas. Low cost, while desirable, does not offset the importance of realism and reasonableness of the proposed cost. Proposal selection will be based on the offeror whose proposal is determined to represent the best value based on the following: If all offers, in the competitive range, are of approximately equal qualitative (technical and management) merit, the offer with the lowest cost will be selected. However, a proposal may be selected that offers a higher qualitative merit if the difference in cost is commensurate with added value. Conversely, a proposal may be selected that offers a lower qualitative merit if the cost differential between it and other offers so warrants.

Some of the best value characteristics that would apply include:

- The degree to which the TDM concept can make progress from the baseline requirements to the goals identified in the TDM Detailed Equipment Specifications (especially for the mid-spatial frequency surface errors and the reflectivity variations)
- Metrology accuracy
- A shorter schedule for demonstration phase leading to early delivery of a TDM (i.e. for two proposals offering to deliver the same performance TDM at the same cost, the one with a shorter delivery schedule is a better value)
- The degree to which the proposed technology is applicable to a wide range of mirror designs (sizes 2 to 5 times larger, and different / non-circular shapes)

E.4 ATTACHMENTS

The following Appendix E Attachments include essential information and supplemental instructions for proposal preparation.

a. TDM Demonstration Phase Statement of Work and Delivery Schedule
b. Sample TDM Work Breakdown Structure
c. TDM Demonstration Phase Cost Plan Instructions
d. Supplemental Information

ATTACHMENT E.4.a TDM DEMONSTRATION PHASE STATEMENT OF WORK AND DELIVERY SCHEDULE

STATEMENT OF WORK AND DELIVERY INSTRUCTIONS

1.0 Demonstration Phase participants shall complete the final design, fabrication, testing, evaluation, and delivery of the proposed Technology Demonstration Mirror. In addition, the Technology Provider's organization shall provide informational and/or other support including reports and reviews presented to JPL and NASA (e.g., Quarterly Governing Program Management Council Reviews, etc.).

2.0 Schedule of Deliverables:

Deliverable	Schedule	Description (see paragraphs below for details)
Monthly Progress Reports	Monthly	Electronic format summary report of progress, status, issues, problems, and resolution plans
Monthly Visits to the Contractor's Site by JPL	Monthly	One day visit to contractor or subcontractors site to assess progress and status
Quarterly Progress Reports	Every 3 months	Electronic format summary report of progress achievements, milestones, schedule, and financial status
Demonstration Phase Kick-off Meeting	1 week ARO*	Review action items and outstanding issues from the Study Phase PDR
Demonstration Phase Delta PDR	+2 months after above	Review the disposition of action items / issues from the PDR and/or Kick-off Meeting
Critical Design Review	+4 months after above	Presentation of the TDM final design, build-to-specifications, and test plans
TDM Test Readiness Review	+10 months after above	Review TDM test plans, assess readiness of TDM and required test facilities to begin testing; subject to TPF concurrence
TDM Test Report	+13 months after above	Final report on test configurations, results, and analysis of TDM testing / characterization
Acceptance Data Package	+2 weeks after above	Report on as-built configuration information such as drawings, schematics, test set-ups, etc.
Pre-Ship Review	Same as above	Validate readiness of TDM and GSE to be shipped to JPL
TDM & GSE	+2 weeks after above	TDM and all associated ground support equipment
TPF Primary Mirror Development Plan	Same as above	Technical specifications, development plan, and management and cost plan, for delivering a TPF flight primary mirror

* *ARO – After Receipt of Order*

Note: Unless otherwise specified, all meetings / reviews will occur at the contractors site or the site of one of the contractor's subcontractors.

2.1. Monthly Progress Reports

The contractor shall provide concise electronic reports monthly which summarize technical progress / status, cost and schedule status, issues, problems, and proposed solutions.

The technical section should be no more than 3 pages if there are no concerns. The schedule and financial information should be in chart form. This report should be received by JPL one week prior to the monthly site visit.

2.2. Monthly Site Visits

The contractor shall permit JPL visits to the contractor's site at least once per month. These one-day site visits are to discuss / view progress against plans, review technical plans and documents (refer to Appendix A, TDM Detailed Equipment Specifications, Contract Data Requirements List for due dates), and discuss major issues, problems and resolution plans.

For the months when the Delta-PDR, CDR, Test Readiness Review, and Pre-Ship review occur, they will take precedence over the monthly site visit. The monthly site visit will occur approximately one week after receipt of the monthly report.

JPL shall be notified and invited to participate in any Material Review Boards.

For critical items (e.g., the mirror blank, coating, etc.) JPL shall have the right for the site visit to take place at the sub-contractor's site. JPL shall be invited to sub-contractor reviews and these reviews can serve as the monthly site visit.

2.3. Quarterly Reports

The contractor shall provide electronic reports quarterly, which summarize achievements, milestones, schedule, and financial status. Pictures of hardware are useful. The purpose of this report is to present an overview of the TDM status to NASA. Delivery of this report will be phased with JPL's need date for preparing quarterly reports to NASA.

2.4. Demonstration Phase Kick-off Meeting

The Demonstration Phase Kick-off Meeting at the contractor's site will review the open action items and outstanding issues from the Study Phase PDR. The purpose is to assure that any changes recommended or made will improve the TDM. Representatives from the TPF science and engineering communities may attend if needed to help reach consensus on resolution plans for system-level issues.

2.5. Demonstration Phase Delta PDR

The Demonstration Phase Delta PDR, to be held at the contractor's site, will review the proposed disposition of action items / issues discussed at the Demonstration Phase Kick-off Meeting. The purpose is to confirm agreement between all parties that any changes planned or made in response to the Kick-off Meeting will improve the TDM design and/or applicability to TPF precursor missions.

2.6. Critical Design Review (CDR)

The CDR, to be held at the contractor's site, will occur after the TDM detailed design has been completed, but prior to the start of deliverable hardware manufacturing. The CDR will examine the compliance of the proposed design to the TDM requirements, highlighting any changes that have occurred since the Delta PDR. The CDR will confirm the readiness to begin hardware manufacture by examining acquisition plans, fabrication plans / drawings, assembly procedures, and acceptance plans for all TDM elements. The aim is to provide confidence that the proposed design, and the planned manufacturing and test methods and procedures, will result in an acceptable product, with minimal risk.

The Critical Design Review shall address all of the TDM specifications in Appendix A.

2.7. TDM Test Readiness Review (TRR)

The TRR, to be held at the contractor's site, will occur prior to the start of formal testing. The JPL TDM Manager must approve the TDM Test Plan before any formal testing is initiated. The TDM Test Plan shall describe the TDM characteristics to be verified by analysis, measurement, or test and the corresponding methodology including pass/fail criteria for each measurement and/or test. Discuss proposed instrumentation, and data acquisition / storage equipment to be used. The intent is to ensure that the test article hardware/software, test facility, personnel, and analysis / test procedures are ready for testing, data acquisition, reduction, and control including complete record keeping of all tests and their results.

The Test Readiness Review will at a minimum examine:

- Design changes since CDR
- Status of non-conformances
- Test documentation (plans, procedures, waivers, pass/fail criteria)
- Facilities and personnel readiness
- Hardware and software configuration

2.8. TDM Test Report

The TDM Test Report shall at a minimum contain:

- A discussion of all verification tests and analysis done
- As tested configuration information (drawings, schematics, etc.)
- Test data, results and analysis for each test conducted
- Witness samples

2.9. TDM Acceptance Data Package

The TDM acceptance data package shall at a minimum contain:

- As built configuration information (drawings, schematics, etc.)
- Verified test procedures and equipment (hardware and software)
- A manufacturing plan document describing the end-to-end procedure for TDM design and fabrication including its processing history
- An optical performance predicative model for zero g and one g conditions
- Outputs from all previous processes
- A statement of provisional acceptance (i.e. TDM readiness for additional testing)
- A transfer document (including a summary of acceptance test results)

2.10. Pre-Ship Review (PSR)

The PSR will be conducted at the end of the TDM demonstration process (design, built, test, evaluation). The PSR verifies the degree to which all elements meet the TDM Detailed Equipment Specifications. It also verifies that testing has been completed with no unacceptable open issues, and verifies the readiness of hardware deliverables, and ground support equipment to be shipped to JPL. The PSR at a minimum, shall cover:

- Determination of completion of testing hardware
- Verification of compliance with the TDM requirements
- Verification and documentation of final hardware configuration
- Identification and status of outstanding safety risks
- Disposition of waivers, deviations, open issues
- Results of compatibility testing of the TDM and ground support equipment
- Results of TDM testing and verification
- Evaluation of the acceptance data packages

2.11. The TDM and GSE

The contractor shall deliver to JPL a Technology Demonstration Mirror. This shall at a minimum include:

1. The TDM assembly (mirror, mounts and flexures, strongback)
2. An appropriate TDM container to prevent damage during transport and/or storage
3. TDM handling equipment and unique test equipment built under this contract

2.12. TPF Primary Mirror Development Plan

As a separate item the contractor shall provide a TPF Primary Mirror Development Plan that describes the technical specifications and development plans, including a schedule and identification of long-lead items and timing, and management and cost plan, for delivering a TPF flight primary mirror.

JPL will provide the contractor with information and requirements for this mirror during the Demonstration Phase.

TPF Primary Mirror Development Plan should be conceptual in nature and cost no more than $50,000.00.

ATTACHMENT E.4.b SAMPLE TDM WORK BREAKDOWN STRUCTURE

1.0 Management
- 1.1. Task Management
- 1.2. Risk Management
- 1.3. Reserves

2.0 Product Assurance & Safety

3.0 TDM Systems Engineering
- 3.1. Design and Analysis
- 3.2. Manufacturing Process Plan
- 3.3. Configuration Management

4.0 TDM Substrate
- 4.1. Blank Design
- 4.2. Blank Acquisition / Fabrication
- 4.3. Blank Test and Verification
  - 4.3.1. Profilometry

5.0 TDM Optical Finishing
- 5.1. Generation
- 5.2. Polishing
- 5.3. Microfinish
- 5.4. Fiducials
- 5.5. Coating

6.0 TDM Test and Verification
- 6.1. Metrology
  - 6.1.1. Full Aperture Measurements
  - 6.1.2. Profilometry
- 6.2. Coating
  - 6.2.1. Reflectance
  - 6.2.2. Uniformity
- 6.3. Structural Loads Analysis and Verification

7.0 Environment Compatibility Verification
- 7.1. Random Vibration - protoflight
- 7.2. Acoustic - protoflight
- 7.3. Pyrotechnic Shock - protoflight
- 7.4. Thermal Vacuum – protoflight
- 7.5. Thermal Cycling - protoflight

8.0 Ground Support Equipment

ATTACHMENT E.4.C TDM DEMONSTRATION PHASE COST PLAN INSTRUCTIONS

The cost plan shall provide sufficient information on the anticipated costs for all aspects of the TDM Demonstration Phase effort to enable a fair and reasonable assessment of the proposed total cost and funding requirements. Cost differs from "funding", which is defined in the Funding Profile section below. The total cost is the total amount of resources used for all activities including any NASA funding from sources other than TPF and all non-NASA funded contributions. This includes direct and indirect costs that contribute to the effort regardless of funding sources. Clearly distinguish between the total cost, the cost to NASA, and the cost to the TPF. Provide a preliminary agreement or endorsement for "leveraged" NASA funding. The total cost shall include the full cost (including the assumptions used to develop the "full cost") of any civil service support to the activity, including technologies provided, project management staff, technical advisors, facilities, etc.

Direct costs that can be specifically related with the TDM Demonstration Phase activity include: (a) salaries and other benefits for employees who work directly on the task, (b) materials and supplies used directly in support of the task; (c) various costs associated with office space, equipment, facilities, and utilities that are used exclusively by the task; and (d) costs of goods or services received from other tasks or entities that are used to produce the TDM.

Indirect costs include resources that are jointly or commonly used to produce two or more types of products but are not specifically identified with any of the products. Typical examples include labor overheads, material handling, cost of money, general administration, general research, and technical support, security, rent, employee health and recreation facilities, operating and maintenance costs for buildings, equipment, and utilities.

Describe the methods and assumptions by which the cost estimates are derived. Cost estimating procedures shall be based upon standard cost accounting principles and practices and shall be in accordance with the proposer's approved accounting system.

Costing of Federal Government elements of proposals shall follow the agency cost accounting standards for full cost. If no standards are in effect for the agency, then follow the Managerial Cost Accounting Standards for the Federal Government as recommended by the Federal Accounting Standards Advisory Board. NASA Centers may submit full cost proposals based on the instructions in the NASA Financial Management Manual, Section 9091-5, Cost Principles for Reimbursable Agreements.

All costs shall be in U.S. real year dollars. Real year dollars are current fiscal year (FY) dollars adjusted to account for inflation in future years. The inflation rate index provided in Table E.4-1 shall be used to calculate all real year dollar amounts unless an industry forward pricing rate is used. Where cost phasing is requested, the cost plan shall provide data by U.S. Government Fiscal Year (October 1 – September 30).

Table E.4-1, NASA New Start Inflation Rate Index

Fiscal Year	2002	2003	2004	2005	2006	2007	2008	2009
Inflation Rate	0.0%	2.8%	2.8%	2.8%	2.8%	2.8%	2.8%	2.8%
Cumulative Inflation Index	1.0	1.028	1.057	1.086	1.117	1.148	1.180	1.213

Provide a Demonstration Phase cost summary by WBS by fiscal year as shown in Table E.4-2.

Table E.4-2 Demonstration Phase Cost Summary by WBS

Demonstration Phase Cost Summary by WBS (All costs in Real Year Dollars)				
WBS / Cost Category Description	FY03	FY04	FY05	Total (RY$)
Total Direct Labor Cost	$	$	$	$
WBS 1.0 Management	$	$	$	$
WBS 2.0 Prod. Assur. & Safety	$	$	$	$
WBS 3.0 Systems Engineering	$	$	$	$
Etc.	$	$	$	$
Total Overhead	$	$	$	$
WBS # and Description	$	$	$	$
:	$	$	$	$
Total Direct Material & Equip. Costs	$	$	$	$
WBS # and Description	$	$	$	$
:	$	$	$	$
Total Subcontract Costs	$	$	$	$
WBS # and Description	$	$	$	$
:	$	$	$	$
Total Other Direct Costs	$	$	$	$
WBS # and Description	$	$	$	$
:	$	$	$	$
Total Indirect Costs	$	$	$	$
WBS # and Description	$	$	$	$
:	$	$	$	$
Total Contingencies	$	$	$	$
WBS # and Description	$	$	$	$
WBS # and Description	$	$	$	$
:	$	$	$	$
Other Costs (Specify)	$	$	$	$
Fee	$	$	$	$
Total TDM Cost	$	$	$	$
Total Other Costs to NASA	$	$	$	$
Other (Specify)	$	$	$	$
Total Cost to NASA	$	$	$	$

Total Contributions by Other Organizations	$	$	$	$
Organization A:	$	$	$	$
WBS # and Description	$	$	$	$
Etc.	$	$	$	$
Organization B:	$	$	$	$
WBS # and Description	$	$	$	$
Etc.	$	$	$	$
Organization Z:	$	$	$	$
WBS # and Description	$	$	$	$
Etc.	$	$	$	$

Total Demonstration Phase Cost	$	$	$	$

The following information regarding categories of cost should be used in generating Table E.4-2:

a. Direct Labor Costs – List by labor category, with labor hours and rates for each. Provide actual salaries of all personnel and the percentage of time each individual will devote to the effort.

b. Overhead – Include indirect costs itemized by fiscal year. Usually this is in the form of a percentage of the direct labor costs.

c. Materials – Provide the total cost of the bill of materials including estimated cost of each major item (include lead time of critical items). Supporting detail for major vendors (exceeding $500,000.00) shall include WBS element, fiscal year, description, vendor name/address, quantity, and current/proposed unit prices. Material burden rates shall be documented.

d. Special Equipment – Include a list of special equipment with lead and/or development time.

e. Subcontracts – Supporting information shall be provided for all subcontracts exceeding $100,000.00. This detail shall include name/address, cost, fee/profit, and type of contract, basis of selection, and concise basis of estimate, and basis of selection. Include any baseline or supporting studies.

f. Other Direct Costs – Other direct costs (such as travel) shall be summarized by category and totals for each fiscal year. Regarding travel, provide an additional summary listing the estimated number of trips, destinations, duration, purpose, number of travelers, and anticipated dates.

g. General and Administrative (G&A) Expense – G&A expense includes the institution's general and executive offices and other miscellaneous expenses related to business.

h. Cost of Money (COM) – COM represents interest on borrowed funds invested in facilities.

i. Profit/Fee (if applicable) – Document the basis, rate, and amount of profit.

j. Other Costs – Costs not covered elsewhere

k. Escalation Factors – Identify the escalation factors used to determine real year dollars if different than Table E.4-1.

In addition to the summary of cost information, the following information shall be provided:

1. Summary of Cost Contingencies and Margins – A summary of cost contingencies and margins shall be identified by fiscal year and project element and the rationale for them discussed. The specific means by which integrated costs, schedule, and technical performance will be tracked and managed shall be explained. Management of contingencies and margins, including the management organization person responsible for managing the contingencies, and when and how the contingencies are to be used, shall be discussed. All funded schedule margins shall also be discussed.
2. Funding Profile – Provide a profile of required TDM funding by fiscal year. The funding profile is derived from the cost profile, which is the basis of the proposal. The funding for a given fiscal year is determined from the estimated costs in that year, less funding carried over from the previous fiscal year, plus the forward funding needed to cover the costs of the first month in the following fiscal year. Because of forward funding, costs will not equal funding in any given fiscal year. Total costs shall equal total funding at task completion.

ATTACHMENT E.4.d SUPPLEMENTAL INFORMATION

The following additional information is required to be supplied with the Technology Concept Definition Study Phase Final Report. This information shall be included as Appendices to the report.

1. Resumes – Provide resumes for all key personnel identified in the Demonstration Phase Management and Cost Plan. Include resume data on experience, which relates to the job these personnel will be doing for the proposed investigation.

2. Letters of Endorsement – Signed letters of endorsement shall be provided from the lead representative of all organizations participating in and critical to the Demonstration Phase activity. The information shall consist of, at a minimum, name of the item / support to be provided, scope of the work to be performed, name and location of supplier or subcontractor, proposed award schedule, deliverable items and delivery schedule, proposed performance assurance requirements, commitment to cost bid, and contingency plans if a supplier or subcontractor fails to perform.

3. Statement(s) of Work – Provide a Demonstration Phase draft Statement of Work for all potential contracts (or other agreements) with NASA. Clearly define all proposed deliverables, potential requirements for Government facilities and/or Government services, and a proposed schedule.

4. Past Performance – Discuss relevant experience and past performance (successes and failures) of the major partners in meeting cost and schedule constraints in similar technology demonstration activities within the last five years. Provide a description of each project, its relevance to the proposed technology subsystem experiment, cost and schedule performance, and points of contact (including addresses and phone numbers).

5. Copy of References – All citations given in the final Study Phase Report shall be included as part of an appendix of references, which includes the complete paper and/or a copy of relevant pages as appropriate from a book reference, and an easily understood abbreviation of the publication (e.g., library standard citation or AIAA format).

6. Acronyms List.